CASSAVA VALUE CHAIN INDUSTRIAL AT BORDER CAMBODIA-THAILAND

PEUO VIBOL

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Thesis
entitled
CASSAVA VALUE CHAIN INDUSTRIAL AT BORDER CAMBODIA-THAILAND

....
Mr. Peuo Vibol
Student

....
Assoc. Prof. Songsak Mimgratok
Ph.D. (Agricultural Engineering)
Major advisor

....
Assoc. Prof. Thaworn Chimliang
Ph.D. (Animal Science)
Co-advisor

....
Prof. Yagura Kenjiro
Ph.D. (Agricultural Economics)
Co-advisor

....
Asst. Prof. Loetchai Chit-aree,
M.Sc. (Horticulture)
Dean of Faculty of Agricultural Technology
Faculty of Agricultural Technology
Rambhai Barni Rajabhat University

....
Assoc. Prof. Thaworn Chimliang,
Ph.D. (Animal Science)
Program Director
Master of Science Program in
Agricultural Technology
Faculty of Agricultural Technology
Rambhai Barni Rajabhat University

Thesis

entitled

CASSAVA VALUE CHAIN INDUSTRIAL AT BORDER CAMBODIA-THAILAND

Was submitted to the Faculty of Agricultural Technology, Rambhai Barni Rajabhat University for the Master Degree of Science (Agricultural Technology)

on

February 22nd, 2021

....
Mr. Peuo Vibol
Student

....
Asst. Prof. Bancha Wiangsamut,
Ph.D. (Philosophy in Agronomy)
Chair

....
Prof. Yagura Kenjiro,
Ph.D. (Agricultural Economics)
Member

....
Assoc. Prof. Songsak Mimgratok,
Ph.D. (Agricultural Engineering)
Member

....
Dr.Sarawut Sangsawangchote,
Ph.D. (Marine Science)
Member

....
Assoc. Prof. Thaworn Chimliang,
Ph.D. (Animal Science)
Member

....
Asst. Prof. Loetchai Chit-aree,
M.Sc. (Horticulture)
Dean of Faculty of Agricultural Technology
Faculty of Agricultural Technology
Rambhai Barni Rajabhat University

....
Assoc. Prof. Thaworn Chimliang,
Ph.D. (Animal Science)
Program Director
Master of Science Program in
Agricultural Technology
Faculty of Agricultural Technology
Rambhai Barni Rajabhat University

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Thesis Advisors

Associate Professor Dr. Songsak Mimgratok — Chairman
Ph.D. (Agricultural Engineering)

Associate Professor Dr. Thaworn Chimliang — Member
Ph.D. (Animal Science)

Professor Dr. Yagura KenJiro — Member
Ph.D. (Agricultural Engineering)

Abstract

Besides rice, which is the major agricultural product in Cambodia, the farmers are also attracted to cassava production. However, there is still a lack of information and research about the cassava value chain which include important factors for the optimal production of cassava in Cambodia. The objectives of this study were to identify the benefits and challenges of cassava production in order to provide recommendations that will generate better income for all the stakeholders in the cassava value chain. A multistage random sampling technique was used to select a group of 109 farmers, 6 transporters/collectors, 6 silo owners, 6 input suppliers, and 3 groups of discussion. Battambang and Pailin Provinces were chosen to study.

The results indicated that the value added and the net profit of cassava famers represented 78.32% and 28.88% of the total production per hectare, respectively. The production cost was $1,057.19 USD per hectare and the breakeven point for a profit was $43.79 USD per ton, with a return on investment of 40%. Moreover, dried chip cassava obtained a 17% greater net profit over fresh root cassava. Labor costs range between 21% and 25% of the revenue from the production. Among the stakeholders, the farmers are the ones who created the highest value added, but the intermediaries (silos) obtained the highest profit. However, the silos play an important role in the cassava production and the farmers would not secure full benefits without their support. The inappropriate practices in agriculture are the cause of the large fluctuation in the yield of cassava. It varies from 10 to 34 tons per hectare. Additionally, there is poor investment in the processing of raw material and a dependence on the Thai traders who do the exporting to the Chinese market. All of this has a strong influence on cassava farming and represents a significant disadvantage for the added value chain of the Cambodian farmers.

Thus, it is highly recommended to have their participation in all the stages of the cassava value chain. This can be done by strengthening coordination among stakeholders, the adoption of field-specific technologies, good management of practices, 4R nutrient concept and applying novel processing technologies.

KEY WORDS: Break Even Point/ Cassava Value Chain/ Value Added/ Cambodia-Thailand border

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รองศาสตราจารย์ ดร.ทรงศักดิ์ มิ่มกระโทก Ph.D. (Agricultural Engineering)	ประธานกรรมการ
รองศาสตราจารย์ ดร.ถาวร ฉิมเลี้ยง Ph.D. (Animal Science)	กรรมการ
ศาสตราจารย์ ดร. Yagura Kenjiro Ph.D. (Agricultural Economic)	กรรมการ

บทคัดย่อ

นอกจากข้าวที่เป็นการผลิตอาหารหลักในประเทศกัมพูชา เกษตรกรยังนิยมปลูกมันสำปะหลังอีกด้วย อย่างไรก็ตามยังขาดข้อมูลสารสนเทศและงานวิจัยเกี่ยวกับห่วงโซ่อุปทานผลผลิตมันสำปะหลัง ที่เป็นปัจจัยสำคัญสำหรับการผลิตมันสำปะหลังในระดับที่เหมาะสมที่สุดในประเทศกัมพูชา วัตถุประสงค์ของการศึกษาครั้งนี้เพื่อบ่งชี้ข้อได้เปรียบและส่งเสริมการผลิตมันสำปะหลังเพื่อที่จะให้คำแนะนำที่สามารถสร้างรายได้ที่เพิ่มขึ้นให้กับทุกองค์ประกอบของห่วงโซ่อุปทานสินค้ามันสำปะหลัง ข้อมูลที่ใช้ในการวิเคราะห์มาจากการเลือกกลุ่มตัวอย่างจากการสุ่มแบบหลายขั้นตอน ประกอบด้วย เกษตรกร จำนวน 109 ราย ผู้ขนส่ง/ผู้รวบรวมจำนวน 6 ราย ผู้ประกอบการไซโลจำนวน 6 ราย ตัวแทนผู้จำหน่าย จำนวน 6 ราย และกลุ่มอภิปราย 3 จำนวนกลุ่ม โดยเลือกพื้นที่ศึกษาในจังหวัดพระตะบอง และจังหวัดไพลิน

ผลการศึกษา พบว่ามูลค่าเพิ่มและกำไรสุทธิมีค่าเป็นร้อยละ 78.32 และ ร้อยละ 28.88 ของการผลิตทั้งหมดต่อเฮกตาร์ มีต้นทุนการผลิตเท่ากับ 1,057.19 ดอลลาร์สหรัฐต่อเฮกตาร์ และมีจุดคุ้มทุนเท่ากับ 43.79 ดอลลาร์สหรัฐต่อตัน ที่ให้ผลการตอบแทนต่อการลงทุนร้อยละ 40 นอกจากนี้พบว่ามันสำปะหลังแห้งสามารถทำกำไรสุทธิสูงกว่าสำปะหลังสดถึงร้อยละ 17 มีต้นทุนการผลิตเป็นค่าแรงงานรับจ้างอยู่ระหว่างร้อยละ 21 ถึงร้อยละ 25 ในองค์ประกอบทั้งหมด เกษตรกรเป็นผู้ที่สามารถสร้างมูลค่าเพิ่มสินค้าของมันสำปะหลังได้มากที่สุด แต่ผู้ประกอบการไซโลขนาดกลางที่ได้กำไรมากที่สุด อย่างไรก็ตาม ผู้ประกอบการไซโลมีความสำคัญอย่างมากต่อการผลิตมันสำปะหลังและเกษตรกรไม่สามารถได้รับประโยชน์อย่างเต็มที่ถ้าไม่มีผู้ประกอบการไซโล การผลิตมันสำปะหลังที่ไม่เหมาะสม เป็นสาเหตุที่ทำให้ปริมาณผลผลิตผันผวนซึ่งผันแปรได้ตั้งแต่

10 ถึง 34 ตันต่อเฮกตาร์ นอกจากนี้การขาดงบประมาณในการจัดซื้อเครื่องมือ และวัสดุอุปกรณ์ในการปลูกและความไม่แน่นอนของผู้ประกอบการชาวไทยที่ส่งออกมันสำปะหลังไปยังตลาดในประเทศจีน ปัจจัยดังกล่าวเหล่านี้ มีอิทธิพลอย่างมากต่อการผลิตมันสำปะหลังและส่งผลให้เกิดความเสียเปรียบอย่างใหญ่หลวงในการเพิ่มมูลค่าห่วงโซ่อุปทานของเกษตรกรชาวกัมพูชา

ดังนั้นข้อเสนอแนะสำหรับเกษตรกรผู้ปลูกมันสำปะหลัง คือการเข้าไปมีส่วนร่วมในองค์ประกอบห่วงโซ่อุปทานซึ่งสามารถทำได้โดยการสร้างความร่วมมือที่เข้มแข็งระหว่างองค์ประกอบ การนำเทคโนโลยีทางการเกษตรที่เฉพาะเจาะจง การบริหารจัดการที่ดี แนวคิดการบริหารจัดการธาตุอาหาร 4R (4R Nutrient concept) และการประยุกต์ใช้เทคโนโลยีใหม่ๆ

คำสำคัญ : มันสำปะหลัง, ห่วงโซ่คุณค่า, จุดคุ้มทุน, ชายแดนกัมพูชา-ไทย

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LIST OF ABBREVIATIONS

AFSIS	ASEAN Food Security Information System
CAVAC	Cambodia Agricultural Value Chain
CIAT	International Centre for Tropical Agriculture
DFID	Department for International Development
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Food and Agriculture Organization of the United Nations, Statistics
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German Development Organization)
IBC	Inclusive Business for promoting sustainable Cassava smallholders project
IPNI	International Plant Nutrition Institute
KHR	Khmer Riel (Cambodian currency)
KII	Key Information Interviews
MAFF	Ministry of Agriculture, Forestry and Fisheries
MIH	Ministry of Industry and Handicraft
NBC	National Bank of Cambodia
NIS	National Institute of Statistics
OAE	Office of Agriculture Economics
OECD	Organization for Economic Cooperation and Development
RDI	Research and Development Institute
SNV	Netherlands Development Organization
SWOT	Strengths, Weaknesses, Opportunities and Threats
THB	Thai Baht (Thai currency)
UBB	University of Battambang, Cambodia
UNDP	United Nations Development Program
USD	United Stated Dollar (America currency)

CHAPTER I

INTRODUCTION

1.1 Background of study

Agriculture is the most important sector in the Cambodian economy. It plays an important role in improving the economy, reducing poverty and building social sustainability. In 2017, the whole agriculture department contributed to 26.7% of the Gross Domestic Product (GDP), which includes crops production of 15.8% (MAFF, 2017). Besides rice, which is the major food production in Cambodia, the farmers, the local and international traders, and industries are attracted to cassava production. Indeed, China's dominance of the global cassava trade is driven, in part by the domestic policy that places a priority on bio-fuel production. As a result, cassava growing areas have risen remarkably. For the last 5 years, cassava production areas in Cambodia expanded exponentially from less than 515 thousand hectares in 2014 to a peak of more than 650 thousand hectares in 2018. And Cambodia produced 13,817,262 tons in 2017 (MAFF, 2017).

Cassava is the 21^{st} century crop and 2^{nd} main crop in the world. Between 1980 and 2011, the global harvested area of cassava expanded by 44 percent, from 13.6 million to 19.6 million hectares (FAO, 2013). Cassava has a kind of root crop that is convenient to grow; it is tolerant to drought, and resistant to insects and illness (FAO, 2007). As mentioned above, biofuel is an important new area of cassava usage in Asia. One ton of dried chips yield about 300 liters of 96% pure ethanol (CIAT, 2015). As countries seek to reduce both dependence on imported oil and greenhouse gas emissions, companies in China, Japan and the Republic of Korea are obtaining concessions for large-scale cassava plantations, mainly in Cambodia, Indonesia, Lao PDR and the Philippines, as a source of dried chips for ethanol production (MAFF, 2015).

In conclusion, cassava production will continue to be developed, especially its value chain such as technical production and marketing. As technical production improves, it will extend to all farming areas. As for marketing, it will be promoted both in local and international levels. As a result, the living standard of the farmers will improve and they will become prosperous from the cassava production.

1.2 Research rationales

Cassava, an agro-industry crop, is used in Asia as feedstock for the production of biofuel. Besides rice, which is the major food production in Cambodia, the farmers are attracted to cassava production. Cassava has now become an important cash crop for resource-poor farmers in Cambodia (Sopheap et al., 2008). Millions of Cambodian smallholder farmers depend on cassava production for their livelihoods. In 2017 Cambodia produced 13,817,262 tons (MAFF, 2017). Recently, China has become a big market for cassava production in Cambodia. However, Cambodian cassava industry is almost exclusively dependent on the border markets of Thailand and Vietnam which act as cassava trade-brokers between Cambodian and International and/or Chinese markets. Therefore, the nature of the product on the one hand and the lack of organized market system on the other hand have resulted in low price for the producer. Besides, there are challenges associated with cassava production and marketing, mainly about the knowledge of grading, market information, excessive intermediaries, price seasonality, and limited number of buyers. Despite the importance of cassava in the livelihood of many farmers and income generating in the study area, it has not been given due attention. Cassava value chain and its characteristics have not yet been studied in this area. Hence, this study attempts to fill in these gaps.

1.3 Significant of the study

Good knowledge of each step of the value chain for cassava is a very important aspect of promoting value added in cassava. This study might then measure and unveiling causal the cassava yield variations to improve technologies and optimal management practices will help in reaching that narrowing of yield gap in cassava production. In addition, the transformation of cassava to dried chips, the value added, the break-even point, and the return on investment is shown. These are important factors to find out what kind of management could increase cassava production and its profitability and guidance for interventions. It should be a tool for them to use in solving problems and would improve efficiency in a specific area. Therefore, the information generated from this study will also help a number of organizations, research and development organizations, traders, producers, policymakers, extension service providers, NGOs, to reach their activities and redesign their mode of operation. Ultimately, it will influence the design and implementation of policies and strategies. It can also help the actors to find and analyze new ways of stimulating the value chain upgrading strategies. Furthermore, this study could be used as material for further study.

1.4 Research questions

1. What are the opportunities and constraints faced by each actor in the chain?
2. Why the yield gap is a very substantial variation in cassava farming?
3. What are advantage and challenge in the cassava value chain?
4. Which actor will achieve the highest profit in cassava value chain?

1.5 Objectives of the research

1. To identify benefits and challenges in the cassava value chain
2. To recommend improvements income generation in the cassava production and distribution at the Cambodia-Thailand border

1.6 Research conceptual framework

- What are the main constraints for Cambodian smallholders and which promotional instruments are most suitable for improving the situation of smallholders in the given Cambodian context?
- The main constraints for Cambodian smallholders in the value chain are also determined. And lastly, the value chain upgrading strategies provided benefits to all actors involved.

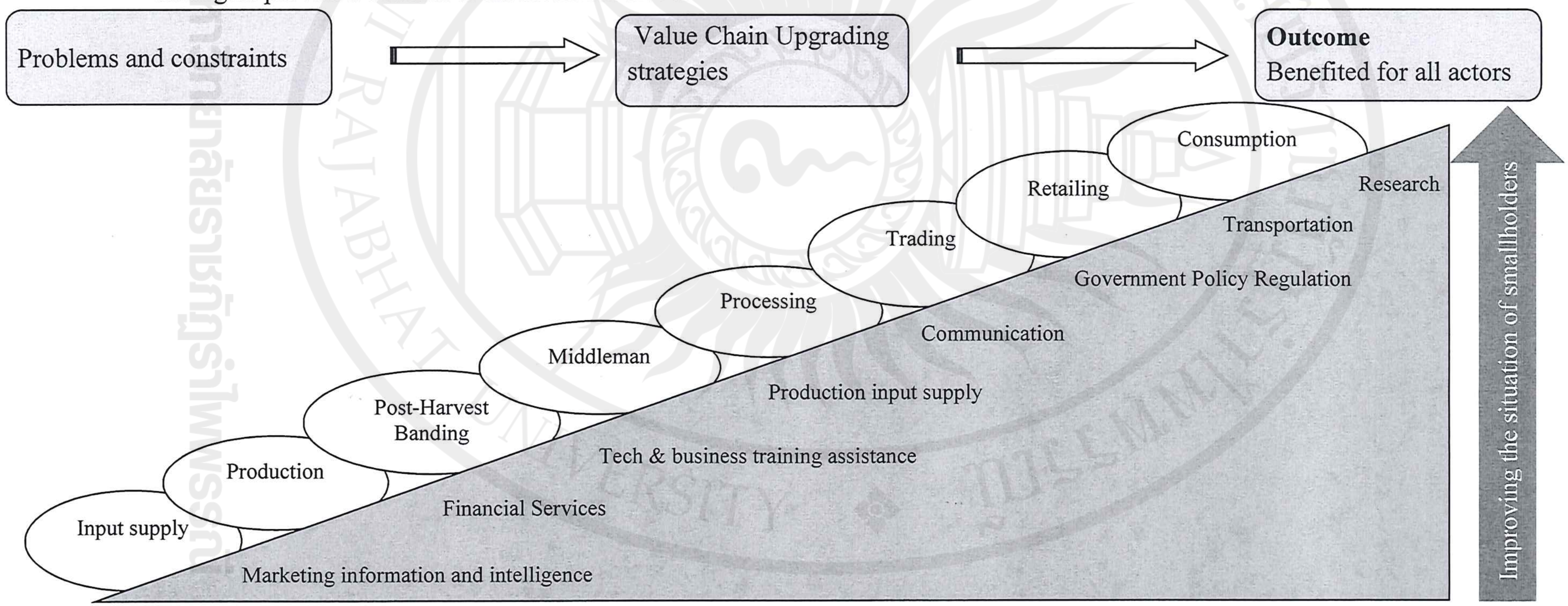


Figure1.1 The main constraints for Cambodian smallholders in the value chain

1.7 Research benefits

The research will try to find out an appropriate technical model to improve the net revenue. It will also emphasize the lack of economic power of the target beneficiaries compared with more powerful firms. These firms set the rules of the game in the value chain and it show how the beneficiaries have limited choices. The research will be useful for decision makers and other stakeholders. It will give them the opportunity to take more actions and introduce new techniques to help rural people livelihood. It will help to decrease poverty and increase food security at community level.

1.8 Scope and limitations of the research

The study is conducted in two borders provinces named Battambang and Pailin. The survey had determined that those which are part of an agro-ecological zoning, have many silos for storage and they export their cassava mainly to Thailand where people produce cassava as the main occupation and are involved in the cassava value chain. The study focuses on the input supplier, the cassava farmers, the cassava collectors, and storage of cassava. The questionnaires will be applied to 109 farmers who have been on cassava farming, also 6 input suppliers, 6 Collectors/Transporters 6 silo managers and 3 groups discussion across 3 districts and 2 provinces who be interviewed. The study is to show all agro-practices and the aspects of the economy in the cultivation of cassava. The first was conducted between February and March 2019 in Battambang province and the second from June to July 2019 in Pailin province. The non-experiment data will contribute to the key finding quantitative data.

CHAPTER II

LITERATURE REVIEW

2.1 Overview of study area

2.1.1 General situation of Battambang

Battambang province is located in the Northwest of Cambodia. The bordering provinces are Banteay Meanchey to the north, Pursat to the east and south, Siem Reap to the northeast, and Pailin to the west. The western part of Battambang province forms part of the international border with Thailand. In addition, the Tonle Sap lake forms part of the northeastern boundary, between Siemreap and Pursat. Its capital and largest city is Battambang with a population of 1,036,523. It ranks as the third most populous province. The province's fertile rice fields have led to a mostly agricultural economy, Battambang is called "the Rice Bowl of Cambodia

2.1.2 General situation of Pailin

Pailin is a province in the western part of the Kingdom of Cambodia located at the northern edge of the Cardamom Mountains near the border with Thailand. This province is surrounded by Battambang Province entirely. It was officially carved out of Battambang to become a separate administrative division after the surrender of the Ieng Sary faction of the Khmer Rouge in 1996. Pailin is known for its natural resources, namely precious gems and timber and it has some potential with agricultural farming such as orchards: Durian, Rambutan and Longan. And also cash crop such as cassava, corn, and soya beans, mung beans, sesame, peanuts, etc.

2.1.3 Cassava in Battambang and Pailin

In Battambang and Pailin, where more than 90 percent of the production is on sloping land, excessive rain, erosion and declining soil fertility and, poor planting materials. Two provinces stand out for cassava farming, namely Battambang with 134,385 hectares and BanteayMeanchey with 101,841 hectares but Pailin has 56,087 hectares. However, the cassava harvest was just 65 percent of the total crop planted in the Tongle Sap Lake Zone compared to 83 percent of the cassava crop harvested in the Plains zone and 74 percent harvested in the Plateau and Mountainous Zone.

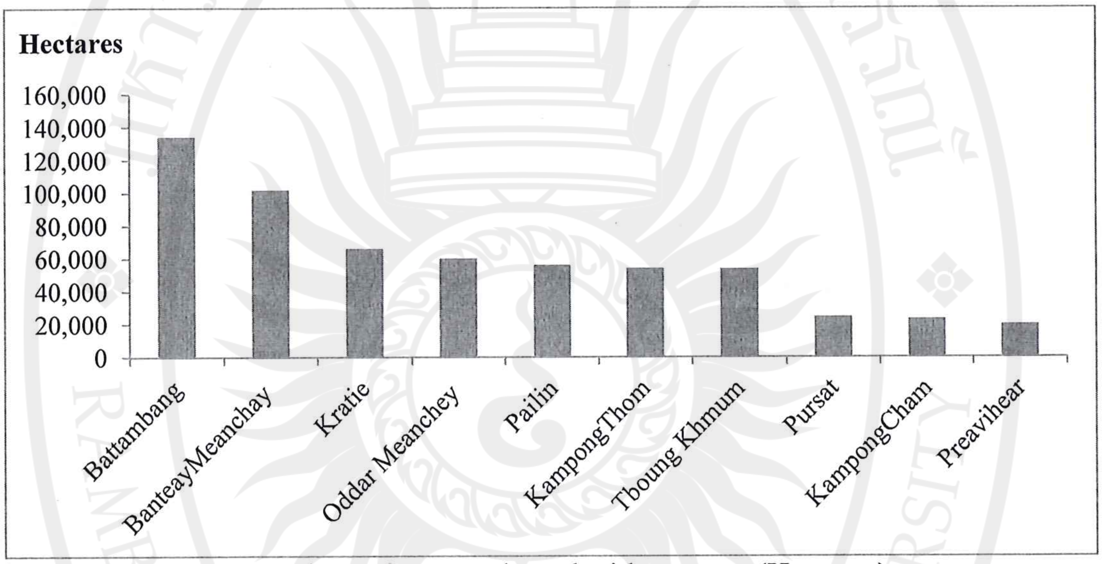


Figure 2.1 Top 10 Provinces for area planted with cassava (Hectares)
Source: MAFF, 2017

2.2 General information on cassava

2.2.1 General information on cassava

Cassava is a vital food crop in tropical regions especially those in Africa and South America, while countries in Asia that consume cassava a lot are Indonesia and India. Cassava is a tall semi-woody perennial shrub that can easily cultivate and can grow in low-nutrient soil and tolerate drought as well as it has an enormous ability to adapt to different climates. It is originated from regions of South America such as Peru, Mexico, Guatemala, and Honduras. These countries have cultivated cassava for 3,000 to 7,000 years and later expanded to other countries in the world by Portuguese and Spanish. Cassava was expanded to regions of Asia through India, Sri Lanka, Malaysia and Indonesia during the 17th century. In Cambodia and Thailand, there is no evidence when cassava is taken to cultivate, but it is assumed that it might be the same period as Sri Lanka and Philippine during 1786 to 1840 (KURDI, 2018)

2.2.2 Cassava morphology

Cassava is a tropical crop, growing between 30°N and 30°S in areas where annual rainfall is greater than 500 mm and mean temperature is greater than 20 °C. However, some cassava varieties grow well at 2000 m altitude or in sub-tropical areas with annual mean temperatures as low as 16 °C (MAFF, 2015).

Cassava is commonly propagated by stem cutting although it can also be propagated by seed, particularly in plant breeding. The cassava plant propagated from stem cutting produces adventitious roots at the base of the cuttings. Cassava plants propagated from seeds first develop a tap root system. Within 30-60 days, some fibrous roots increase in diameter and become tuberous roots (FAO, 2013).

Cassava is monoecism that means male and female flowers are located on the same plant. The flower production is important for breeding (FAO, 2013). The female flowers open 1-2 weeks before the male flowers (protogyny). The insects carry out cross-pollination and Self-pollination occurs when female and male flowers, located on different branches of the same plant, open at the same time. The fruit matures in 70-90 days (MAFF, 2015).

2.2.3 The 4R Nutrient Stewardship concept

Optimal nutrient management is the key in closing wide yield gaps and in attaining sustainable intensification in cassava. Farmers must be informed that, as with other crops, cassava needs fertilizer to achieve high yields. Continuous cropping of cassava without balanced fertilizer application can lead to soil nutrient depletion and yield decline over time (Luar et al., 2018).

4R Nutrient Stewardship concept of applying the right source of plant nutrients at the right rate, at the right time, and in the right place (IPNI, 2012) provides guidelines on fertilizer management that will help farmers reap the full benefits of their investment in fertilizer. The following are practical tips for applying 4Rs in cassava:

Right Source

• Determine the availability of fertilizers or nutrient sources and check their nutrient content.

• Mixture of single and compound fertilizers can be used as long as it satisfies the nutrient requirement of the crop to achieve a certain target yield.

• Check the price of the fertilizer source. The increase in benefit coming from the increase in yield of cassava through fertilizer application can mask the additional cost.

• Use farm-available nutrient sources such as plant residues and animal manure. These organic nutrient sources can also improve soil properties.

Right Rate

• Use site-specific fertilizer dosage, if available.

• Determine the nutrient requirements of the crop. High-yield varieties need higher fertilizer dosage than low-yield varieties.

• Determine the fertility status of your soil. Soils with high fertility supply more nutrients than their low fertility counterparts.

• Consider other bio-physical constraints. Low yield is expected in sites that are prone to water retention or drought.

• Fertilizer rates can be adjusted based on farmer's budget for economic yield. Farmers with budget constraints can opt to target relatively lower yield, therefore reducing fertilizer rates and investment.

• Over application of any particular fertilizer is not economical. Do not apply excessive amounts of N, as it will increase crop foliage and sacrifice tuber yield (Sangakkara & Wijesinghe, 2014).

Right Time

• Apply N, P, and K fertilizer, 2 to 4 weeks after planting to ensure that the crop has enough nutrients to support its early growth.

• Moderate rates of N fertilizer can be divided in two or three applications to increase N recovery efficiency and induce good yields (Sangakkara & Wijesighe, 2014).

• A full dose of P should be applied in the first application to support root development.

• K fertilizer may be divided in two to three applications to minimize losses (i.e., if the required rate is high or if the soil is lightly textured).

• Ensure that soil moisture is sufficient and weeds surrounding the plants are removed before fertilizer application.

• Application of fertilizer during heavy rain is not advisable. It can cause nutrient losses due to erosion and leaching.

Right Place

• Make sure that the fertilizer is easily accessible to the plant roots.

• Apply the fertilizer 15 to 20 cm from the base of the plant and cover with soil by hilling-up or by drilling holes. This can also minimize nutrient losses due to volatilization and run-off.

2.2.4 World cassava production

Cassava growers in Asia account for 30 percent of world production. Since the year 2000, Asia's cassava production has increased by 55 percent, as more countries seek to enter the lucrative export market. The region's major customer is China. Between 2000 and 2009, China`s annual import of dried cassava grew from 256,000 tons to more than 6 million tons, while imports of cassava starch has more than doubled, at 1.2 million tons (FAO, 2013).

Africa has harvested 140.9 million tons in 2015 and increased to 160.7 million tons in 2018, more than half of the global harvest. Nigeria is the highest producer in Africa, second is Democratic Congo and third is the Republic of Ghana. It is still essentially a food crop, as around 90 percent of harvested roots are destined for human consumption, while around 10 percent is semi-processed as on-farm animal feed in sub-Saharan Africa (FAO, 2018).

Table 2.1 World Cassava production

	2015	2016	2017	2018
	(000 tons)			
World	**277,072**	**276,510**	**275,655**	**277,070**
Africa	**152,822**	**155,607**	**157,453**	**160,730**
Nigeria	57,643	57,855	55,069	56,000
Congo, Democratic	15,300	15,200	14,950	15,200
Republic of Ghana	17,213	17,798	19,138	19,441
Angola	7,727	7,788	7,740	7,724
Mozambique	8,103	9,100	10,920	12,198
Tanzania, United	5,886	5,575	5,300	5,400
Republic of Uganda	2,898	2,885	2,950	2,980
Malawi	4,997	5,089	5,100	5,030
Benin	3,421	4,096	4,079	3,725
Cameroon	5,000	5,170	5,346	5,400
Rwanda	3,000	3,179	3,427	3,701
Madagascar	2,677	2,629	2,523	2,650
Côte d'Ivoire	5,087	4,548	5,367	5,370
Other Africa	13,870	14,693	15,545	15,911
Latin America	**32,309**	**30,279**	**29,915**	**30,593**
Brazil	23,060	21,080	20,610	20,940
Paraguay	3,000	3,167	3,167	3,250
Colombia	2,092	2,117	2,125	2,250
Other Latin America	4,157	3,915	4,013	4,153
Asia	**91,689**	**90,383**	**88,051**	**85,511**
Thailand	32,358	31,161	30,495	27,240
Indonesia	21,801	20,261	19,046	21,000
Viet Nam	10,740	10,925	11,263	10,500
India	4,373	4,344	4,171	4,073
China, mainland	4,500	4,548	4,550	4,560
Cambodia	11,944	13,222	13,387	13,000
Philippines	2,711	2,733	2,792	2,652
Others Asia	3,261	3,190	2,348	2,486
Oceania	**252**	**241**	**236**	**236**

Source: FAO, 2018

2.2.5 World export of cassava production

In Asia, industrial demand for cassava is in the form of ethanol, starch and animal food, and their lucrative export markets, especially China, have underpinned strong expansion of the crop in the past decade, particularly in Southeast Asia. In the past decade, Thailand was the main cassava export country in Asia. Vietnam and Cambodia were second and third (FAO, 2018).

Table 2.2 World export of Cassava production (product weight of chips and pellets)

	2014	2015	2016	2017	2018
			(000 tonnes)		
Total	**19,948**	**22,061**	**21,765**	**21,805**	**13,874**
Flour and Starch	**9,068**	**9,040**	**9,749**	**9,576**	**7,354**
Thailand	7,919	7,657	8,446	8,290	6,400
Viet Nam	788	1,011	1,055	1,048	800
Cambodia	29	56	64	146	80
Others	333	316	183	93	74
Chip and Pellets	**10,880**	**13,021**	**12,016**	**12,229**	**6,520**
Thailand	6,927	7,458	6,411	6,661	3,900
Viet Nam	2,995	3,607	3,241	3,200	1,200
Cambodia	808	1,805	2,182	2,230	1,300
Others	150	150	181	137	120

Source: FAO, 2018

2.3 Present situation of cassava production in Cambodia

2.3.1 Cassava production

In Cambodia, there are two main types of cassava: Sweet cassava and Bitter cassava. The Sweet cassava is commonly grown for family consumption and bitter cassava is generally grown for animal feed or as a raw material for processing industries (Huang et al., 2002). The situation has dramatically changed within the last 5 years as it became the second major crop in the country in terms of both cultivated area and production quantity (MAFF, 2014). The cultivated area of cassava increased dramatically from less than 26,000 hectare in 2003 to nearly 400,000 hectare in 2011. There was a slight decline in 2012 with 320,000 hectare cultivated, but it increased again to about 421,000 hectare in 2013. Along with a rapid expansion in the production areas, the national average yield for cassava also increased significantly, although with some slow decline in the later years. The situation resulted in a vast increase in total cassava production from about 0.33 million tons in 2003 to nearly 8 million tons in 2013. Expansion of planted areas of cassava is probably due to an increased demand of cassava chips for ethanol production by the international markets, particularly Chinese market (Aye, 2014).

Table 2.3 Crop production (%) in agricultural land in Cambodia from 2010- 2013

Ranks	Crops	2010		2011		2012		2013	
		Hectare	%	Hectare	%	Hectare	%	Hectare	%
1	Rice	2,795,892	79.51	2,968,529	77.6	3,007,545	76.71	3,052,420	76.44
2	Maize	205,070	5.83	174,257	4.56	216,330	5.52	239,748	6
3	Cassava	190,525	5.42	391,714	10.24	361,854	9,23	421,375	10.55
4	Soybean	101,904	2.9	70,584	1.85	71,337	1.82	80,688	2.02
5	Mungbean	66,265	1.88	68,111	1.78	66,850	1.71	54,312	1.36
6	Vegetables	49,873	1.42	53,757	1.41	76,495	1.95	52,449	1.31
7	Others	106,690	3.03	98,354	2.57	120.017	3.06	92,456	2.32
Total production area		**3,516,219**	**100**	**3,825,306**	**100**	**3,920,428**	**100**	**3,993,448**	**100**

1/ Source: MAFF Annual Report 2011, 2012, 2013, 2014

2/ Including peanut, sugar cane, sweet potato, sesame, jute and tobacco

2.3.2 Cassava varieties

At the present time, no cassava breeding program has been either established or carried out in Cambodia. There has been some testing only of varieties from cassava breeding centers located in countries like Thailand, Vietnam or China. The results of such testing have confirmed the suitability of some varieties such as KU 50 and Huay Bong 60 (from Thailand), and varieties SC8 and SC9 from China (MAFF, 2015).

There are two types of cassava planted in Cambodia, a sweet variety or it is called in local language Damlong Kor or Damlong Mi. It contains low hydrogen cyanide (HCN) concentration and is appropriate for direct consumption. The second type is the bitter variety which is used for industrial purpose. According to a survey conducted by (Ou et al., 2016), more than 85% of the farmers in Kampong Cham cultivated KU 50 (also called Malay variety), while more than 80% of farmers in Pailin grew Kartoil variety.

2.3.3 Cassava propagation

The national cassava field bank in Cambodia is traditionally maintaining a wide variety of cassava cultivars and landraces, which are adapted extensively to different conditions. The field bank uses them for research and distribution of the germplasm to different users. It comes with the technical simplicity of readily available vegetative material for immediate research purposes and also with a high vulnerability to pest and diseases. Battambang, one of the largest cassava producing provinces in the country, initiated cassava tissue culture propagation in 2011. Subsequently, a Cassava Propagation and Distribution Center (CPDC) were established at the UBB farm in 2013 supported by the Government of Japan to extend the propagation of disease-free materials under insect-proof screen house conditions. This Center consists of two screen houses with the capacity to produce 10,000 stakes annually. Establishment of this Center allowed UBB to conduct cassava field days for provincial extensionists and demonstrating the importance of using disease-free materials to the farmers for sustainable cassava production (Tokunaga et al., 2018).

2.3.4 Pest and disease issues

Cassava originates from South America. When it arrived in Asia it benefited from a long period of absence of pest and disease. In the recent past, several phytosanitary concerns have become more serious throughout the entire region. Cassava witches' broom, a phytoplasma disease, has now spread across cassava production area from Thailand to The Philippines and subsequent reports were made in several other Asian countries (Pardo et al., 2014).

The Plant Disease journal published a report of Sri Lankan cassava mosaic virus (SLCMV): in a single plantation in Ratanakiri province of northeast Cambodia, the Cassava Mosaic Disease has been identified. Until then, Cassava Mosaic Disease (CMD) had only been known to be found in Africa and parts of the Indian subcontinent. To date, Cambodian and Vietnamese authorities have officially reported the presence of CMD in seven provinces in eastern and central Cambodia, and ten provinces in southern Vietnam (Wang et al., 2016).

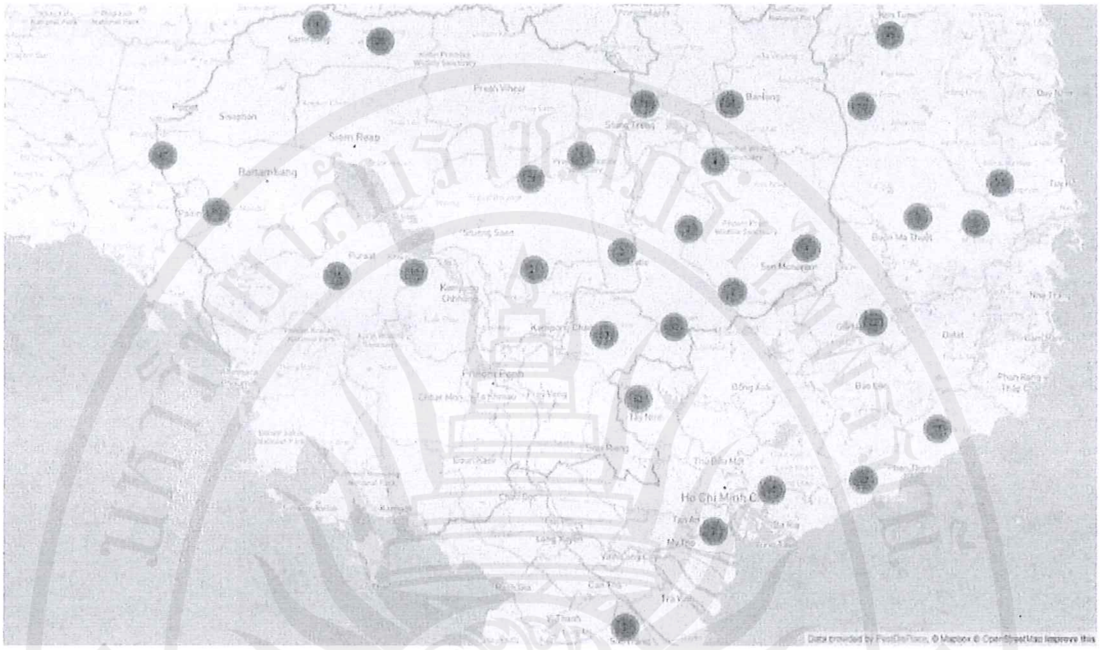


Figure 2.2 Map of Cassava Mosaic Disease (CMD) in South East Asian
Source: CIAT, 2015
Red: Confirmed diagnostics **Green:** Collected

The main taxonomic groups of arthropods relevant to cassava in South East Asia are Mealybug Mite and Whitefly (CAIT, 2015). 24 species of mealybugs have been reported from cassava production worldwide, with eight species being relevant to South East Asia. Table 2.4 shows that Papaya mealybug species was first reported from Asia in 2008, with records from Indonesia and India and more recently it was detected in Cambodia, Thailand and The Philippines. Cassava "witches ' broom" (CWB) has been reported in Asia in 1993 in Thailand, It has affected 64% of the fields in several prime cassava-growing areas, and it was especially problematic in Cambodia where 78% of the cassava fields were impacted by CWB (Ignazio et al., 2016).

Table 2.4 Main pest and disease pressures in Southeast Asian cassava

Pests/Disease	First record	Estimated Yield loss	Details
Cassava mites	2009-Indonesia	Up to 50% yield loss in Indonesia (Shylesha, 2013)	Caused by defoliations, top of the plant, often killing apical and lateral buds and shoots.
Cassava mealybug	2009-Thailand	Up to 84% loss recorded. Initial estimates from Thailand 20-40% (Parsa et al., 2012)	Can colonize at least 9 different agricultural species
Papaya mealybug	2008-Indonesia	10-40% yield loss (Winotai et al., 2010)	Detected in Cambodia in 2010. Can live on more than 80spp. of plants.
Striped mealybug	1942-Thailand	Estimated at 20-80% (Bellotti et al., 2013)	Can colonize over 272 plant spp. Including coffee, guava, cashew, citrus, and cassava
Cassava witches broom	1993-Thailand	90 % loss of starch content (Lozano et al.,1992)	Caused by 16Srl phytoplasma. Causes severe stunting
Sri Lanka Cassava Mosaic Virus	2015-Cambodia (previously India and Sri Lanka)	30–40% yield loss (Thresh et al., 1997)	Potentially devastating disease causing leaf mottling, loss, and plant death. High potential impact. Little research on impacts in Southeast Asia

Source: CIAT, 2015

2.3.5 Cassava myths and realities

Cassava production is surrounded by many misunderstandings. Some commonly repeated information about cassava production is based more on myth than on fact. To evaluate some of this misinformation, this factsheet explores the most common myths and realities about cassava cultivation.

Myth 1: Cassava destroys soil fertility

Over the years, continuous cropping and inappropriate farm management leads to net nutrient removal and gradual decline of soil fertility. Nevertheless, the same is true of all crops. Is cassava worse in this regard than other crops? Howeler (2002) showed the average of the major nutrient by cassava root as compared to the harvested product of other crops: Nitrogen (N) and Phosphorus (P) removal per ton of dry matter (DM) in cassava root were actually much lower than that removed by sweet potato, while that potassium (K) was similar or lower than wheat. When cassava root yield was very high, the N and P removal per hectare was similar to that of wheat while K removal was indeed higher than that of any crop such as sweet potato, sugarcane, and tobacco (Table 2.5).

Table 2.5 Average nutrient removal (kg/ha and kg/t harvested product) by crops

Crop/Plant Part	Yield(t/ha)		Nutrient removal					
			Kg/ha			(DM) Produced Kg/ton		
	fresh	Dry	N	P	K	N	P	K
Cassava / roots	35.7	13.53	55	13.2	112	4.5	0.83	6.6
Sweet potato / roots	25.2	5.05	61	13.3	97	12	2.63	19.2
Maize / grain	6.5	5.56	96	17.4	26	17.3	3.13	4.7
Rice / grain	4.6	3.97	60	7.5	13	17.1	2.4	4.1
Wheat / grain	2.7	2.32	56	12	13	24.1	5.17	5.6
Sorghum / grain	3.6	3.1	134	29	29	43.3	9.4	9.4
Beans / grain	1.1	0.94	37	3.6	22	39.6	3.83	23.4
Soya / grain	1	0.86	60	15.3	67	69.8	17.8	77.9
Groundnut / pod	1.5	1.29	105	6.5	35	81.4	5.04	27.1
Sugarcane / cane	75.2	19.55	43	20.2	96	2.3	0.91	4.4
Tobacco / leaves	2.5	2.1	52	6.1	105	24.8	2.9	50

Source: Howeler, 2002

Myth 2: cassava is a 'low maintenance' crop. It does not need fertilizer.

Reality: Like any crop, cassava achieves its best yields under proper management. With a lack of inputs to replenish the nutrients removed by harvest, yields will decline. Howeler (2002) showed a yield decline due to continuous cassava production in the same unfertilized plot over 8 years period (Figure2.3). These trends are typical of other similar experiments in Southeast Asia.

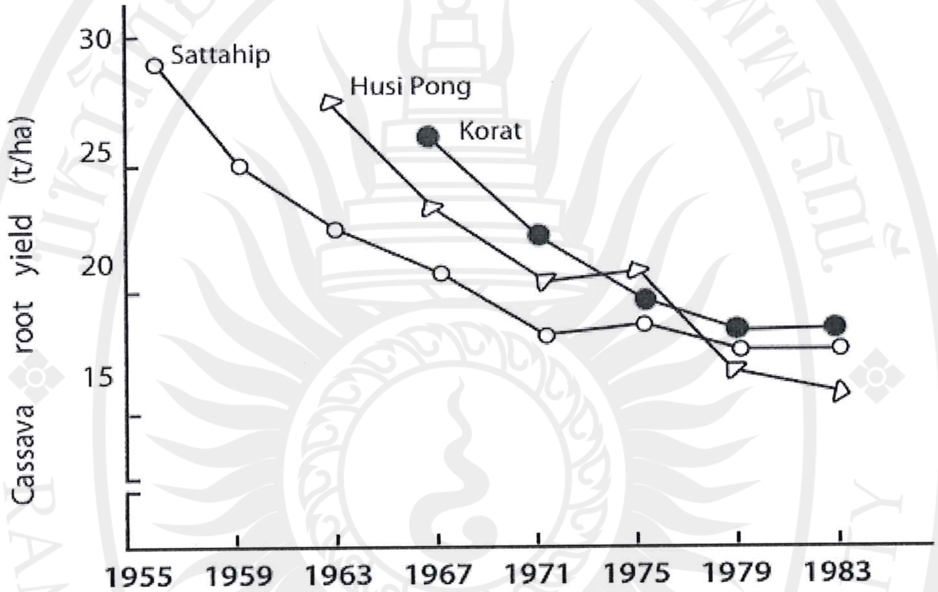


Figure 2.3 Demonstrates yield decline over an eight year period in Thailand
Source: Howeler, 2002

While the yields vary based on seasonal conditions, the yield decline can be minimized. Over the years, many participatory trials have shown that even a relatively conservative application of fertilizer in the appropriate balance of N: P: K; applied at the right time, and with appropriate placement, can provide farmers with very attractive returns on investment. Farmers in Cambodia are often not aware of the correct type of fertilizer, of the appropriate dosage, or when to apply the fertilizer to the crop.

2.3.6 Yield gap cassava production

A study in Kampong Cham province, in Cambodia revealed large variations in yield among farmers' fields, ranging from 12.7 to 37.2 tons per hectare. The fields were divided into five yield categories, with the mean yields of the lower four categories ranging from 76.0 to 34.2% of the maximum yields, with corresponding yield gaps ranging from 8.9 to 24.4 tons per hectare. The main yield constraints identified were soil nutrient deficit, short crop duration and weed competition. However, for different fields with similar yield levels, the main production constraints sometimes differed. The results clearly indicated that there are opportunities for yield improvement and narrowing of yield gaps through the adoption of field specific improved technologies and management practices (Sopheap et al., 2012).

2.3.7 Extension system of cassava

Exploring existing extension and understanding socioeconomic situation of cassava farmers are essential. That knowledge will help to establish the sustainable extension scheme of healthy cassava seedlings with the necessary technologies and know-how of the farmers for the sustainable production (Tokunaga et al., 2018). The Department of Agricultural Extension (DAE) of the Ministry of Agriculture, Forestry, and Fishery (MAFF) was established in 1995 and has the mandate to lead and coordinate the extension and technology transfer activities. The extension of agricultural techniques has been undertaken by a number of stakeholders such as NGOs and international donors though adoption of new techniques. But the technologies used by the farmers are quite limited; the reasons are multiple: a lack of funding, poor techniques, poor material, lack of human resources and limited extension methodology (MAFF, 2015). The Cassava association 74 (CA), which connects cassava companies or cassava producers in Cambodia, is about to be established. This association will promote cassava contract farming and it will benefit the participants. But it is still unknown how the CA will work on cassava dissemination and will go along with the Cambodian government (Tokunaga et al., 2018).

2.3.8 Cassava exporting

The annual value of cassava starch (or tapioca) traded globally exceeds any other form of native starch. Modified starches, sweeteners and syrups, and various fermentation products and acids derived from cassava grown in Asia are utilized throughout the world. The demand for cassava production in Cambodia is still very low, with only 19.24% of cassava exported in 2009. Thailand's export was 18.75%. But Vietnam's export was 62%, which is why the price of cassava is down sharply.

Table 2.6 Demand for cassava production in Cambodia 2009

Demand of Cassava	Type of Cassava	Demanded (Ton)
Cambodia	Starch	124,000
	Bio-Fuel	200,000
	Consumption	30,000
	Feeding	30,000
	Total	384,000
Vietnam	Unspecified (dried)	1,236,740
Thai	Unspecified (dried)	374,400
Total		**1,995,140**

Source: MOC, 2014

In 2016, The Statistics, Ministry of Commerce showed that Cambodia's exports of dried and fresh cassava hit about 2,910,176 tons. In 2013 Cambodia exported only 2,041,600 tons (MOC, 2014)

Cambodia exported about 2,431,617 tons of dried chips (87% to Thailand, 9% to Vietnam and 4% to China), and 438,250 tons of fresh cassava roots (90% to Vietnam and 10% to Thailand). In addition, Tapioca starch was exported: about 24,098 tons to China (88%) and 12% to USA, Canada, Austria, Europe, and Malaysia. Additionally, between 2013 and 2016, the export of fresh/dried cassava has been increasing annually, while cassava starch has been increasing a little bit (MOC, 2014).

Table 2.7 Cassava exports from Cambodia to other countries in 2016

Cassava Products	China	Thailand	Vietnam	Austria	Canada	New Zealand	Malaysia	UAS	Italy	Others	Total (Ton)
Sliced (Ton)	77,917.79	2,111,549.23	242,150	0.012	-	-	-	-	-	-	2,431,617
Fresh (Ton)	-	41,500	396,750	-	-	-	-	-	-	-	438,250
Tapioca Starch	21,208.50	-	-	-	440	54	357	747	1,224	68	24,098.50
Cassava reside	16,211.05	-	-	-	-	-	-	-	-	-	16,211.05

Source: MAFF, 2017

Regarding FAO report, Cambodia has produced more than 11,944,000 tons in 2015 and will continue to grow to 13,000,000 tons in 2018. Cambodia's major cassava market (Fresh and Dried) is Thailand, China, and Vietnam.

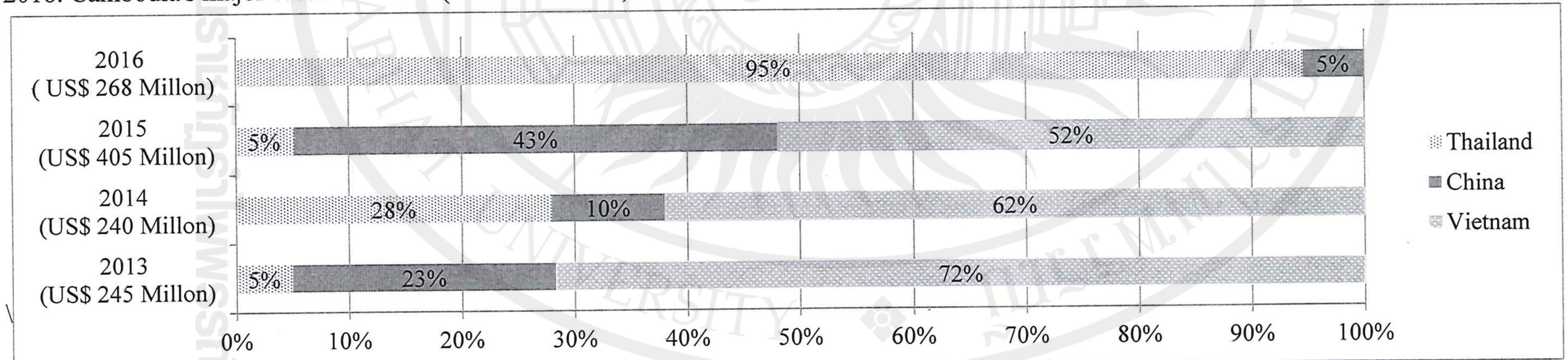


Figure 2.4 Cambodian cassava exports major markets, 2013-2016
Source: OECD, 2017

2.4 Value chain theory

2.4.1 Definition of value chain

The value chain describes the full range of activities which are required to bring a product or service from conception through the different phases of production (involving a combination of physical transformation and the input of various producer services), delivery to final consumers, and final disposal after use. Considered in its general form, it takes the shape as described in Figure 2.5. The term value chain refers to the full range of activities that are required to bring a product (or a service) from conception through the different phases of production, to delivery to consumers and disposal after use (Kaplinsky & Morris, 2001).

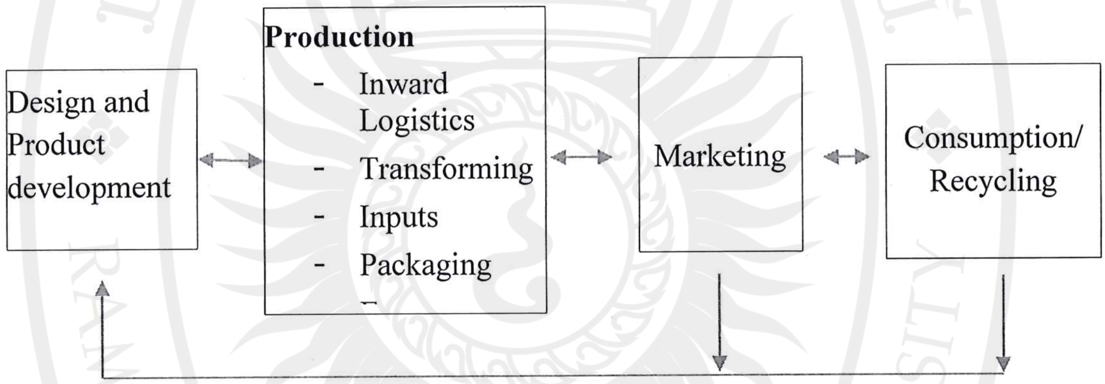


Figure 2.5 Four links in a simple value chain

Source: Kaplinsky & Morris, 2001

2.4.2 Concepts of value chain

The value chain concept has proven particularly useful for the identification and formulation of projects as well as in the development of strategies for improving the agricultural and rural development. According to Gebremedhin (2009), in the agricultural value chain, there are four major basic concepts: value chain, stages of production, vertical coordination, and business development services.

Value chain is more helpful than orthodox theory in explaining why the poor may face barriers to trade and how to overcome them. This is because orthodox theory uses a series of empirically questionable assumptions to provide an overarching answer to a wrong question. The link between trade and economic growth, on one hand, and poverty reduction, on the other hand, has never been a central focus of trade theory. An orthodox theory fails to deliver plausible intervention for policymakers and for practitioners, who have more modest goals: how to support an identified target group to access (or be on better terms with) specific viable value chains (Jonathan et al., 2009).

2.5 Handbook and research papers in Cambodia

2.5.1 Cassava value chain analysis

The annual work plan of Cambodia Agricultural Value Chain Program (CAVAC), project Gender and Disability Strategy, 2010 is an important tool in the search for a better income, while maintaining a sustainable environment. The choice to work in the cassava sector must be seen in the context of improving the income of the poor in the rural area, while ensuring that there are no detrimental environmental impacts (CAVAC, 2010).

Cassava culture is a fairly intensive labor, with CAVAC estimating that there are about 75 man/day (md) involved in the cultivation of one hectare of cassava. However it was estimated that in 2008, that figure were 100. The ability of cassava to be stored in the ground by delaying the harvest allows it to be used as a food bank during food scarcity.

There are two main characteristics of cassava that ensure that it is an important crop for the rural poor as followed:

1. Domestic demand: In 2009, 17% of the total demand for cassava (2.4 million tons) was for domestic markets.

2. International demand: In 2009, the exports to Thailand represented only 40% of 2008 level and the exports to Vietnam had recovered to an estimated 43%. International demand: In 2009, the exports to Thailand represented only 40% of 2008 level and the exports to Vietnam had recovered to an estimated 43% (CAVAC, 2010).

2.5.2 Cassava product flows and roles of market participants

The study also analyzes the cassava marketing system in Pailin province. Cambodian farmers serve as the first link in the cassava market chain in Pailin province, followed by local traders and wholesalers (Sreyneang, 2016)

Cassava farmers: The cassava producers have two links in the value chain: from the farm gate, it goes to the local processing factory and then to the Thai importers. The Figure 2.6 indicates that the most prominent buyers of both cassava forms (fresh and dried chips) are the wholesalers who buy 93% of fresh cassava and 74.19% of cassava chips while 25.82% flow through local processing firms. The rest of the fresh cassava roots flow through local collectors, accounting for 7%. The majority of the cassava product flows through the wholesalers because they act as the main buyers in the province. The local traders still play an important role, even though they can only buy at a lesser volume compared with other traders. The local collectors have links to the producers, who usually can not afford to transport their produce to the wholesalers, especially the small-scale producers who reside far from the city. In some cases, the producers are able to sell directly to the local processing firm if they have large-scale operations or can afford the costs of transporting their products. Some of the producers reside near the local processing firms (Sreyneang, 2016).

Local collectors: After deducting processing losses (approximately 50%), the remaining cassava chips flow through to three linkages, which are wholesalers (1.91%), local processing firms (1.91%) and Thai Importers (0.73%), (Sreyneang, 2016).

Wholesalers: Wholesalers buy from producers both in dried chips and fresh forms. They buy fresh cassava and process this into dried chips for selling to Thai importers and local processing firms. Wholesalers buy about 93% of fresh cassava roots from producers. The majority of the products accounting for 73.28% are distributed to Thai importers while very little goes to the local processing firms 1.56% (starch processing and feed firm), (Sreyneang, 2016).

For the dried chips, the wholesalers buy almost 74.18% of dried cassava chips from producers and about 1.91% from local collectors. From these amounts, storage losses represent approximately 2% (Sreyneang, 2016).

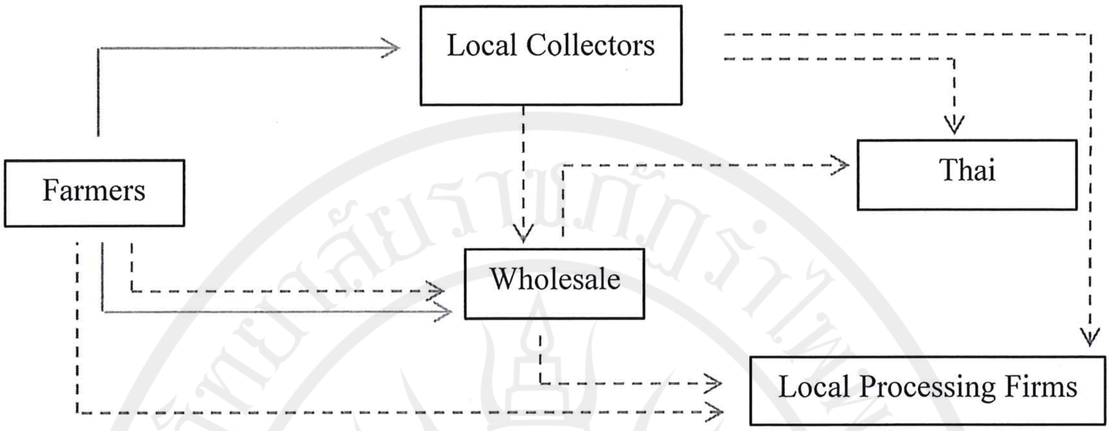


Figure 2.6 The Cassava Marketing mapping, Pailin Province, 2014

Note: - - - - -> Flow of cassava chips ——> Flow of fresh cassava roots

Source: Sreyneang, 2016

Farmers claimed a higher share to end-user's price (45.11%) followed by local collectors (29.60%) and wholesalers (19.65%). Marketing cost has a negative effect to the profit of cassava marketing agents. In order to improve the marketing efficiency of cassava in Pailin Province, marketing cost at farm and intermediaries level should be minimized. Policy directions like the establishment of an effective market information system, promotion of local processing firms, establishment of required post-harvest facilities, and improvement of road infrastructure are suggested (Sreyneang, 2016).

2.5.3 Economic analysis of cassava production

The costs that were considered here are from variable sources like labor, transportation, fertilizers and pesticides usage, and others. The labor cost represents the highest amount (47.2%), followed by the transportation cost (31%), fertilizers and pesticides usage (9%), others (12.8%). So, the labor represents the highest Total Variable Cost. Gross margin result indicate that farmer obtain a net return of 1,269,487 riels per hectares with a benefit-cost ratio of 1.31 (Sopheak, 2017).

2.5.4 Breakeven point

In Pursat province, Cambodia, the break-even point for dried chips cassava production in 2017 was 376,310 Riels (94$) per ton, with an average yield of 10.78 tons per hectare. Around 32% of the cassava farmers of that province lost profit from their cassava production because of the uncertainty of the market system and the lack of policy support on the cassava chain (Vibol, 2019).

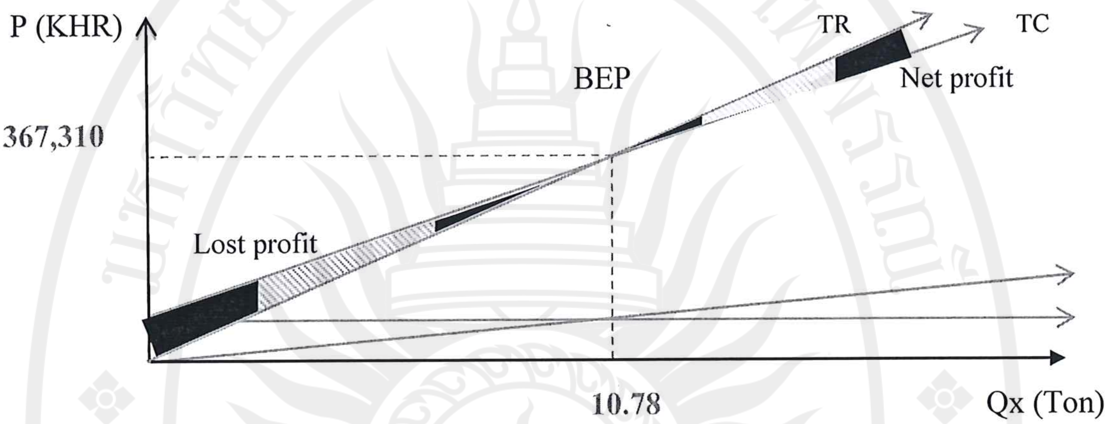


Figure 2.7 (BEP) in dried chip Pursat Province, Cambodia, 2017
Source: Vibol, 2019

2.5.5 Use of labor in farm production

According to the Social Economic surveys of NIS, 51% of Cambodia's labor force worked in agriculture in 2012, representing 3.9 million workers out of 7.7 million in the total labor force. In 2005, it was 57 percent. And in 2013, labor use declined to 48 days, or by 34 percent (Table 2.8). Labor use also declined for maize and dry season rice, but increased for vegetable production, which in principle is hard to mechanize.

Table 2.8 Use of labor in farm production by crop, Cambodia, 2005 and 2013

Crops	2005 Days/hectare			2013 Days/hectare	Change (%)
	Family	Hired	Total	Total	
Paddy (Wet season)	30.3	42.7	73	48.29	-34
Paddy (Dry season)	24.6	48.7	73.3	27.75	-52
Cassava	13.2	35.2	48.4	48.8	1
Maize	15.6	26.2	41.8	31.33	-25
Vegetables (mix)	79.8	60.1	139.9	169.85	2

Source: NIS, 2015

2.5.6 Cost of cassava production

In Asia, the cost to produce cassava varies from one country to another; In India, it is $ 900 per hectare, the highest cost in Asia. The country's cheapest cost is in. The Philippines, where it only costs $ 300 per hectare (FAO, 2013).

Table 2.9 Cost of cassava production in Asia

Items	China	India	Indonesia	Philippines	Thailand	Vietnam
Labor Costs ($/h)	**167.4**	**421.7**	**185.37**	**218.8**	**167.18**	**213.6**
Labor cost ($/man-day)	1.86	1.29	1.11	2	3.24	1.78
-Land preparation (man-day/h)	7.5	1.5	45	8.1	2.5	5
- Preparation planting material	-	1.9	5	-	-	5
- Planning	15	14.8	15	9.4	9.1	10
- Application fert. and manures		10.7	12	2,5	6.4	5
- Application other chemicals	-	0.3	-	-	-	-
- Irrigation	-	51.9	-	-	-	-
- Weeding and hilling up	40	208.6	40	26.9	8	40
- Harvesting (Includes loading)	22.5	37.2	50	37.5	25.7	55
-Transport and handling	-	-	-	25	-	-
Total (mandays/ha)	**90**	**326.9**	**167**	**109.4**	**51.6**	**120**
Others Costs ($/ha)	260.22	242.15	80.55	163.25	198.73	171.07
-Fertilizer and manures	130.11	159.39	79.44	53.75	61.97	80.36
-Planting material	-	26.83	1.11	25	-	-
Others materials (herbicides, sacks)	37.17	2.23	-	20	25.84	-
- Transport of roots	-	-	-	-	70.38	-
- Land preparation by tractor	92.94	53.7	-	64.5	40.54	90.71
Total Variable Costs ($/h)	**427.6**	**663.85**	**265.92**	**382.05**	**365.91**	**384.67**
- Land rent and/or taxes	94.94	236.5	46.67	-	48.89	60
Total Production Cost ($/h)	**520.6**	**900.35**	**312.59**	**382.05**	**414.8**	**444.67**
Yield (T/h)	20	40	20	25	23.4	25
Root price ($/t fresh roots)	29.74	38	17.78	25	21.62	21.42
Gross income ($/h)	294.8	1,520.00	355.6	625	505.91	535.5
Net income ($/h)	**74.24**	**619.65**	**43.01**	**242.95**	**91.11**	**90.83**
Production costs (\$/ t fresh roots)	**26.03**	**22.51**	**15.63**	**15.28**	**17.73**	**17.79**

Source: FAO, 2013

According to the current study on cassava production in Cambodia, for the provinces of Pailin and Kampong Cham in 2013, the average cost per hectare was $ 981 in Pailin and $ 845 in Kampong Cham. On average, more than $900 per hectare (Ou et al., 2016).

Table 2.10 Cost of cassava production in Cambodia

Province	**Kampong Cham**			**Pailin**		
Items	Man-days/h	Labor cost/day ($)	Total cost ($/h)	Man-days/h	Labor cost/day ($)	Total cost ($/h)
Land preparation by hand or 4 wheel tractor	1 Hand tractor	30	30	14 wheel tractors	100	100
Cutting stakes	9	5	45	9	5	45
Planting (Digging& planting)	12	5	60	12	5	60
Fertilizers			150			120
Fertilizer application	3	7.5	15	3	7.5	15
Insecticide spaying	4	7.5	30	4	7.5	30
Herbicide spaying	4	7.5	30	4	7.5	30
Harvesting (root digging & cutting)	50	5	250	50	7.5	375
Carrying	10	5	50	-	-	-
Drying (Chip cutting & drying)	10	5	50	10	5	50
Transport by truck (6t/truck)	4 trucks	31.25	125	5 Trucks	31.25	156.25
Total cost			845			981.25
Yield			**20.13**			**29.27**
Price ($/t)			75.85			62.02
Gross income			1,526.86			1,815.33
Gross margin (2013)			**681.86**			**834.08**

Source: Ou et al., 2016

2.5.7 Cassava value chain analysis inclusive business model for promoting sustainable smallholder cassava production

The SNV Cambodia (2015) study of the cassava value chain was conducted by the IBC (Inclusive Business for promoting sustainable Cassava smallholders). There were many objectives: to map out the key actors and examine the governance, to identify the advantages and challenges resulting from the participation of stakeholders in the cassava value chain, and to highlight the areas of potential impact of a value chain upgrade. The link between the stakeholders was analyzed with the aim of improving their knowledge, as well as proposing appropriate measures for a stronger cassava value chain.

2.6 Handbook and research papers in others countries

2.6.1 The study of cassava supply chain in Kanchanaburi Thailand

The Office of Agricultural Economics of AFSIS (2019) did a study of the cassava supply chain in 2019. The goal was to analyze the production cost and the returns, including the yield per hectare. The study shows that the popular cassava varieties among the farmers are Kasetsart 50, Rayong 5 and Rayong 72. The production cost of cassava with all varieties per hectare is 1,101.90 USD. This is divided into variable cost of 913.92 USD per ha and fixed cost of 187.98 USD per hectare. This gives a total average cost per kg of 0.05 cents USD. For the total returns, the farmers are able to produce at the average amount of 3,325.11 kg and sell their yield at the average price of 0.06 cents USD per kg, making an average income of 145.02 USD per hectare. The total return is 1,246.92 USD. The net return per ha is 1,246.92 USD.

2.6.2 Advancing smallholders' sustainable livelihood through linkages among stakeholders in the cassava value chain: the case of Dak Lak Province, Vietnam

Hoa et al (2019) explored how to improve and develop the value chain, how to increase the stakeholders' income to ensure sustainable household livelihoods. The findings relating to the sharing of value added among the stakeholders showed that the farmers create the highest value added but that intermediaries derive the most profits. The study found that a relationship exists among the different stakeholders, from the input providers to the final users, who are the actors at the level of starch and ethanol factories, in the cassava value chain. Furthermore, the distribution of both gross and net profits overwhelmingly favors the traders and the processors.

2.6.3 Evaluation of income and employment generation from cassava value chain in the Nigerian agricultural sector

Olukunle (2013) found that over 1 million jobs have been created in rural Nigeria for farmers and other actors in the cassava value chain. And there is an increase of income of approximately 450 USD per year for 1.8 million participating farm families. However, although a strong longstanding market has been established in the cassava sector it was found that the farmers gained a smaller percentage of the total profits, compared to the traders who received the largest part of the profit.

CHAPTER III

RESEARCH METHODOLOGY

3.1 Selection of the study areas

This study was conducted in two of the provinces adjoining the Cambodia-Thailand border, Battambang and Pailin, where there is more than 50,000 hectares of cassava area in each province, according to the Ministry of Forestry and Fisheries. The survey has determined that those who are part of an agro-ecological zoning, have many silos for storage and they export their cassava mainly to Thailand. Besides cassava as the main crop, the area cultivates maize, soybeans, mungbeans, and sesame.

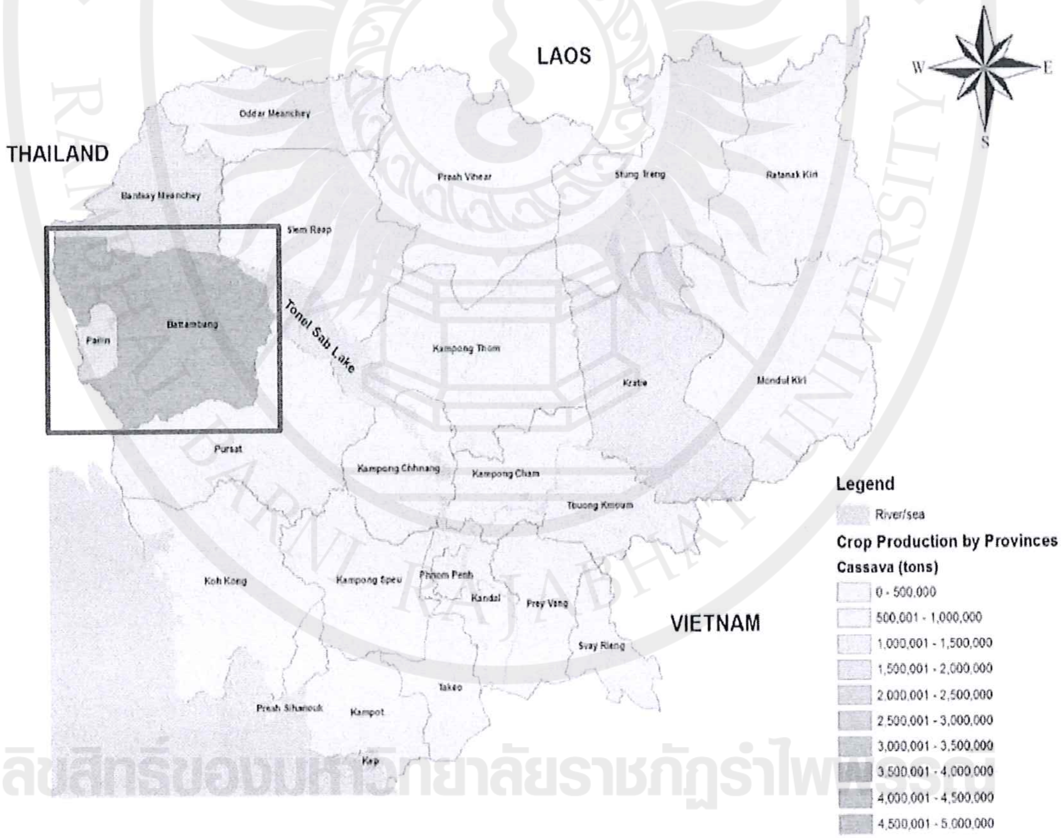


Figure 3.1 Study area (Battambang and Pailin province)

Source: MAFF, 2015

3.2 Sampling method

Sampling of cassava producers: A multi–stage sampling technique was used. Selected producer-respondents were chosen across the 3 districts, 3 communes and 6 villages in Battambang and Pailin province. A total of 109 cassava producer-respondents were chosen from a list collected of the village chiefs. Then a selection was used, from a random sampling technique with a sampling fraction of at least 10 percent.

The number of cassava producers-respondents in each commune was selected proportion to their numbers. The location of the samples for study has been selected according to Taro Yamane formula (created in 1967 & 1973) in terms of finite population. According to Taro Yamane formula, we can calculate the whole sample and sample selected by village as bellow:

$$n = \frac{N}{1 + Ne^2}$$

Where:

N : total population

e^2 : standard error 10%

n : sample selected

N = 1,194 and e = 10 %

$$n = \frac{1{,}194}{1 + 1{,}194(0.1)^2}$$

n = 109 samples

For the numbers of household samples in each village, it is selected by using below formula:

$$n_i = \frac{n \times N_i}{N}$$

n_i : Number of household samples in each village

N_i: Number of total households in each village

n: Number of total household's samples

N: Number of total households in all villages

So, the numbers of household samples for interviewing in each target village is presented in the below as shown in Table 3.1.

Table 3.1 Number of household samples in each target villages

Provinces	Districts	Communes	Villages	Households	Households	
					Cultivated	Selection
Battambang	Sompovlun	Serei Mean Chey	OuKandal	455	308	28
	PhnomPhrek	PhnomPhrek	PhnomPhrek	901	350	32
Pailin	Salakrav	Salakrav	Phnomkuy	386	295	27
		OuAndoung	Ouchetbram	290	241	22
		Total		**1,637**	**1,194**	**109**

Sampling of cassava traders: A total of 12 traders have been selected for the study: For each province of Battambang and Pailin: 6 silos were chosen from a list of agricultural technician department of Agriculture, Forestry and Fishery in the study area. The sample trader-respondents in the cassava marketing system were identified using the tracing method.

Input Suppliers: 6 input suppliers have been selected form 3 districts for the study, based on the sales of fertilizer and pesticide that the farmers have used in their cassava production. The tracing method was used.

Table 3.2 Sample respondents in cassava value chain

Actors		Sample Selected
Producers (Farmers)		109
Traders	Transporters/Collectors	6
	Silos	6
Input Suppliers		6
Group discussion		3
Total		**130**

3.3 Data collection

The study was conducted using a case study approach, which is one of two methods used for social science research. The data collection was from primary and secondary sources.

3.3.1 Secondary data

The secondary data is gathered from various sources: Ministry of Agriculture, Forestry and Fisheries (MAFF), Cambodia; the library of Rambhai Barni Rajabhat University (RBRU), Thailand; the library of Royal University of Agriculture (RUA), Cambodia. The journals, books, local villages and commune offices, relevant ministries and None Government Organization (NGOs), and finally from opinions of concerned sectors involved in the cassava value chain. Field trips were done to gather primary data well as secondary data.

3.3.2 Primary data

➢ The study was conducted using a case study approach, which is one of several methods of conducting social science research (Yin et al., 2009). Data collection was conducted with the aid of structured questionnaires (Fonji et al., 2017). Data relating to household characteristics (Mukete et al., 2018) came from a household survey, interviews with key informants and focus-group discussions with heads of household and actors in the cassava value chain.

➢ Primary data was collected from a sample of actors/stakeholders who are involved in the production, collection, and silo processing along the cassava value chain in both provinces.

➢ Data related to household characteristics came from a household survey. Interviews with key informants and focus-group discussions were done. Personal observations were made to gather information.

➢ To complement the survey, both primary and secondary data were collected from stakeholders who directly participated in the value chain. This includes the input providers, traders and processors. Both in-depth interviews using a semi-structured questionnaire and direct observation in the field were also applied in this study.

3.3.3 Research design

In this study are employed to get details and diverse information on the issues. The usage of these mixed methods also helps to triangulate the information which is gathered. With this, both quantitative and qualitative methods are used via household survey, Key information interviews (KII), and personal observation.

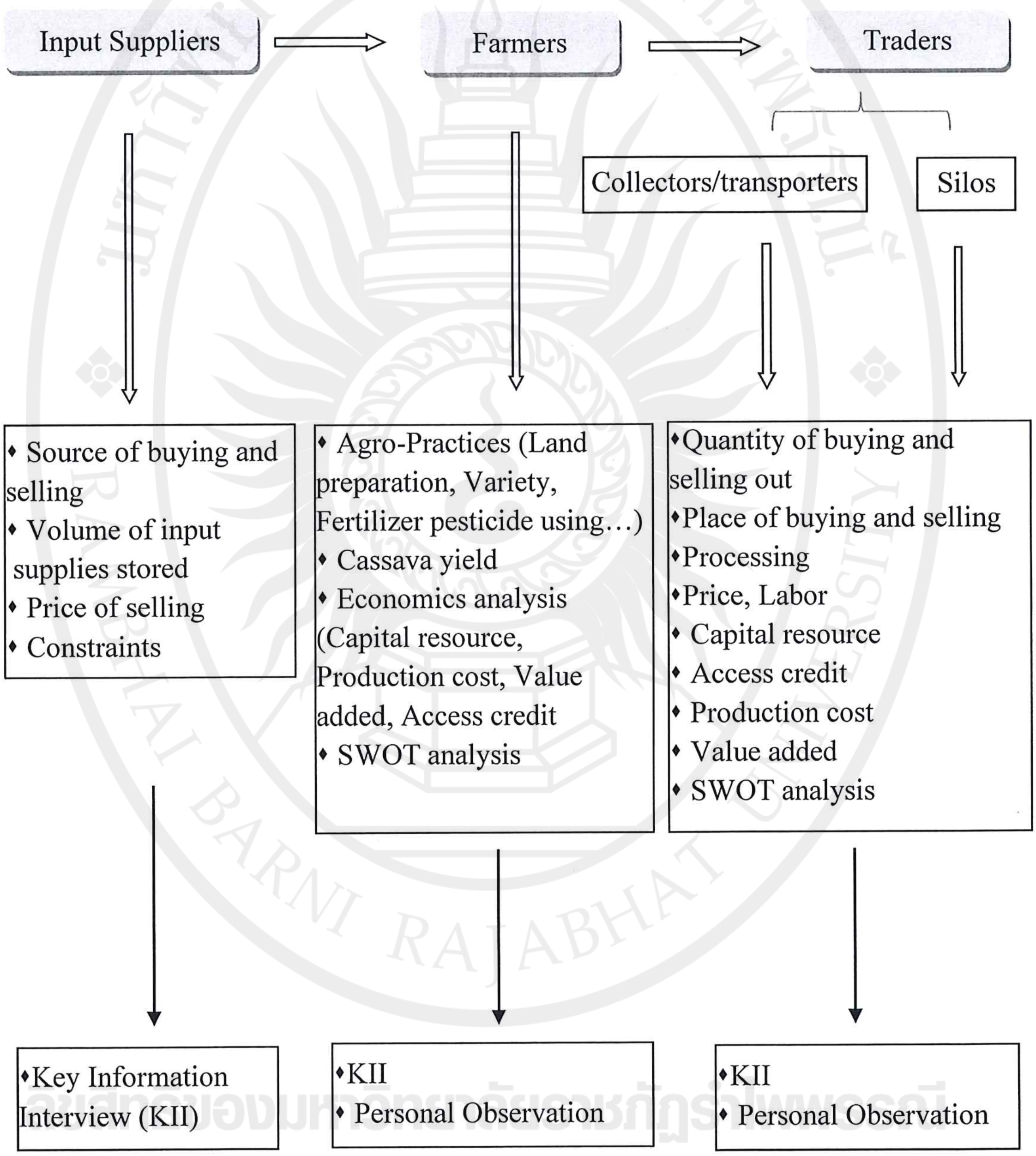


Figure 3.2 Three links in the research design on value chain

3.4 Data analysis

Both qualitative and quantitative methods of analysis were applied in this study to understand the roles and actions of the major actors. The analysis of the data from the questionnaire-based survey involved coding, data entry and analysis using the SPSS statistical program and Microsoft Excel.

The quantitative analysis, simple descriptive statistics such as mean, frequency, and percentages for agro-practices and demographic, agricultural economic data were used for the survey data gathered from sample farm households. SPSS and Microsoft Excel were employed to analyze the data. The analyzed data was presented using tables, graphs, and charts. Addition, the regression analysis was also conducted to examine with agro-practices significantly affect cassava yield as well as to investigate whether farmer's knowledge level represented by education level and farm experience has an influence on cassava yield.

The qualitative data from the in-depth interviews with stakeholders and focus group discussions were analyzed by specific content analysis. The purpose of this method was to identify and examine the most important topics (Masamha et al., 2018). A value chain details the many activities that are required to take a product or service through the different phases of production and then the delivery to the final consumers, and its disposal after use (Kaplinsky & Morris, 2001). The analysis of the cassava value chain was based on the value-chain analysis method (VCA) (Naziri et al., 2014). Value-chain upgrade solutions were computed in this study using a quantitative method. In analyzing the supply stages, the marketing and the trading relationships between actors, the chain analysis has become a key tool, since it can enable an understanding of the whole chain (Meaton et al., 2015).

This study identified major aspects of the cassava value chain at the Cambodia-Thai border province. The production cost, intermediate input (II), value added (VA) and other economic parameters, including gross profit (GPr), and net profit (NPr), (Purcell et al., 2008). These were evaluated based on specific actors' perspectives. Revenues were calculated according to the following equation:

Total Revenues (TR) = (Q × P) + income from by-products

Where TR= is the total receipts a seller can obtain from selling goods or services to buyers. It can be written as P × Q which is the price of the goods multiplied by the quantity of the sold goods. Q = quantity sold and P = price paid by buyer

Components of total value generated by the value chain such as output value (Y) and product value were also calculated using the Q × P formula, based on analytical frameworks for value chain analysis, proposed by international organizations such as Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ, 2007).

Value added (VA) was calculated to measure the new wealth created by a productive activity. And thus the creation of wealth and the contribution of the production process to the growth of the economy. VA was calculated according to the following equation:

$$VA = Y - II$$

Where: Y = total sales (output) value from production

II = intermediate input such as fertilizer, pesticide and seedlings.

Profit elements were calculated as follows:

$$GPr = VA - (\text{wages and salaries} + \text{interest charges} + \text{taxes})$$

$$NPr = GPr - \text{depreciation}$$

GPr expresses the economic gain, or loss, to an actor once all current production costs have been met.

NPr indicates the economic gain or loss taking into account the predictable costs of actual investment.

Budgetary techniques analyzed such as Total cost and Breakeven Point (BEP) and profitability ratio were used to estimate the costs and returns of cassava production in the study area. Farm budgetary analyses enable the estimation of the total costs as well as total revenue accrued to the enterprise within a specific production period (Olukosi & Jenny, 1999).

Break Event Point

Total Revenue (TR) = Total Cost (TC)

$$\Leftrightarrow P_1 \times Q_1 + P_2 \times Q_2 = TC$$

$$\Leftrightarrow P_1 \times Q_1 = TC-(P_2 \times Q_2)$$

$$\Leftrightarrow P1 = [TC-(P_2 \times Q_2)]/Q_1$$

Where:

P_1 : Price of main product per unit

P_2 : Price of sub product per unit

Q_1 : Quantity of main product

Q_2 : Quantity of sub product

The Break-even analysis is a useful tool to study the relationship between fixed costs, variable costs, and returns. A break-even point tells us when an investment will generate a positive return and can be determined graphically or with simple mathematics. The Break-even analysis is divided in 2 types: one type is the price break-even point analysis (sales price varies but the total cost and yield per hectare is fixed). The other type is the yield break-even point analysis (the yield changes due to factors unrelated variable factors - fertilizers, fuel, labor, etc. -). So, the total cost per hectare and the price per ton are fixed.

Economic Efficiency/Benefit-cost ration or return investment

$$E=TR/TC$$

Where: E: Economic efficiency

TR: Total Revenue, $TR= P_1 \times Q_1 + P_2 \times Q_2$

TC: Total Cost, $TC = FC+VC$

Economics Efficiency: We want to know how much benefit they will get for each 1 KHR or 1 USD investment on the production.

A benefit-cost ratio (BCR) is an indicator showing the relationship between the relative costs and benefits of a proposed project, expressed in monetary or qualitative terms.

If a project has a BCR greater than 1.0, the project is expected to deliver a positive net present value to a firm and its investors.

If a project's BCR is less than 1.0, the project's costs outweigh the benefits, and it should not be considered.

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Cassava value chain distribution channel in border

4.1.1 Key stakeholders in the cassava value chain

The key stakeholders in the cassava value chain in Battambang and Pailin province, Cambodia are the input suppliers, the farmers/producers, the collectors/transporters, the processor enterprises (silos), and the exporters. See (Figure 4.1) for the relationship between them and their key characteristics.

The input suppliers are important actors. They supply the agricultural products to meet the farmer demands such as fertilizers, herbicides and pesticides as well as being a source of informal credit for agricultural activities.

The farmers/producers are the first actors in the chain. They are mostly located in rural areas where the infrastructures are often deficient. So these farmers are consequently disadvantaged since they need to supply their fresh root and dried chips cassava to the buyer.

The collectors/transporters can be grouped based on the amount of cassava that they buy, either locally or from other regions. However, their most important activity is the transport of the cassava production from the fields to the silos. Addition, they are strongly to mobilizer the labor force to harvest the cassava in the region.

The processor enterprises (silos) are the wholesalers in the value chain. They buy cassava in both types (fresh roots and dried chips) from the farmers/producers and collectors/transporters. They mostly buy cassava in fresh roots and then process it into dried chips. All of them have close contacts with Thai traders for cassava production exportation.

CP Feed animal industry in the study area buy dried chips from the processer enterprise (silo). Their capacity is about 180,000 million tons of animal feed per year (UNDP, 2019). The cassava from Battambang, Pailin and other provinces near the border is used as raw material by CP Feed Company. It was established in Pailin province in 2018 as a Thai Company.

4.1.2 Cassava marketing mapping in the border

Currently, there are several distribution channels for the cassava to its final industrial processing and to the exporters. However, there are only two major channels and both affect the income of the households surveyed by this study. Firstly, cassava dried chips are supplied to CP Feed animal industry for the processing of animal food, locally (28.77%). The second distribution channel is the supply sent to Thai traders for exporting to Chinese market (3.47% in fresh root and 67.76% in dried chips), as shown in Figure 4.1.

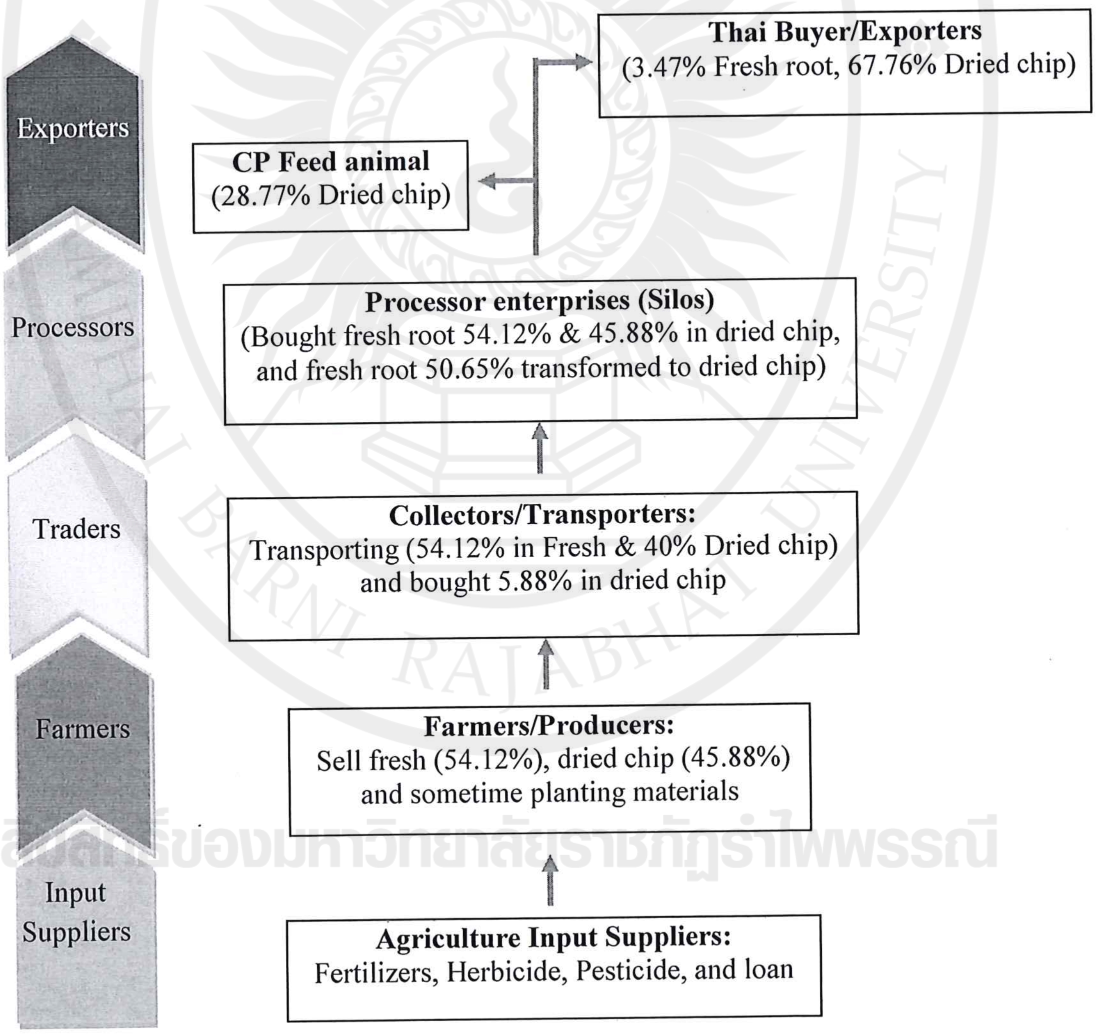


Figure 4.1 Cambodia-Thailand border cassava value chain maps

4.2 Demographic characteristic of cassava farmers

4.2.1 Age of head of households

As shown in table 4.1, the results revealed that 87.16% of the respondents are males and head of household; 12.84% are females and widows. So, cassava farming is a male domination; and this was also the findings of Sopheak (2017).

The age categories for the head of household are as follow: 19-30 years old, represents 12 families (11.01%); 31-40 years old represents 33 families (30.27%); 41-50 years old, represents 26 families (23.85%); 51-60 years old, represents 21 families (19.27%) and there were 17 families (15.60%) with a head of household above 60 years old. So, it is deduced that the head of households aged between 30 and 50 years old represented more than 50% of the total respondents. So, we can say that this category of people is very active in farming and likely to accept new technologies to reduce their risks. Age is an important factor in the adoption of new techniques to improve the agricultural productivity as reported by Ojo & Ogunyemi (2014). Young farmers are more likely to accept new technologies for reducing their risks.

Table 4.1 Household demographic of cassava farmers

Items	Category	Frequency	Percentage	Mean
Gender	Male	95	87.16	-
	Female	14	12.84	
Age	19-30 Years old	12	11.01	44.89 Years
	31- 40 Years old	33	30.27	
	41– 50 Year old	26	23.85	
	51- 60 Years old	21	19.27	
	Above 60 years old	17	15.60	

4.2.2 Education of head households

The level of education of the farmers is one of the factors that affect the agricultural productivity. The major finding in the previous study shown that, farmers who have a secondary school education have the highest returns on agricultural productivity (Oduro et al., 2014). In contrast, a large part of the cassava farmers in our sample study has a low level of education (41.29% of them have a primary school, diploma as their highest education). A major effect of education in agriculture is the cognitive effect, whereby a farmer acquiring basic literacy and mathematic can read the instructions of usage on fertilizers, pesticides, and herbicides and can calculate the right mix of input to enhance productivity (Appleton & Balihuta, 1996). The survey in Cambodia showed that 16.51% of the farmers were illiterate or had no schooling, 41.29% attended a primary school, 28.44% attended a secondary school, 11.01% attended high school and only 2.75% attended college (Figure 4.2). Their ideas on cassava production are more often based on myths of facts, like thinking that cassava does not need fertilizers or pesticides.

As a result, we can assume that their education level is low and that they lack information about marketing, techniques, weather factors and pest mitigation. The knowledge of these factors could improve their productivity.

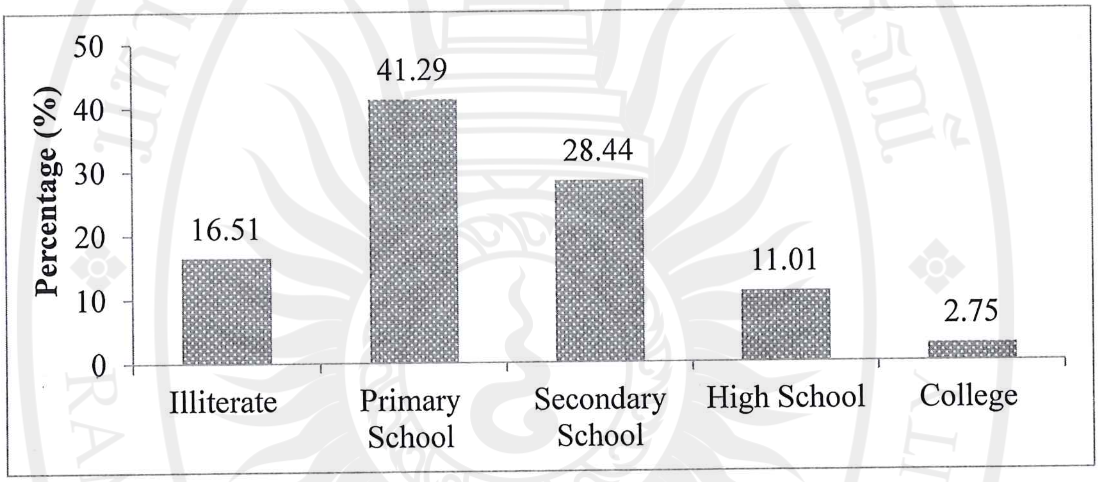


Figure 4.2 Education levels of head households' cassava farmers

4.2.3 Ownership of the land of households

According to the data presented, the farmers have an average land holding size of 7.63 hectares, which is 37.67% of reclaimed land, 33.32% of purchased land, 10.41% of inherited land, and 18.60% of rented land as showed in Figure 4.3. This indicates that 81.40% of the farmers own their land and 18.60% are not the owners of their land. Hence, the average own land size was 6.21 hectares while 1.42 hectares were from rented land. Most of the land for cassava farming has not been registered yet.

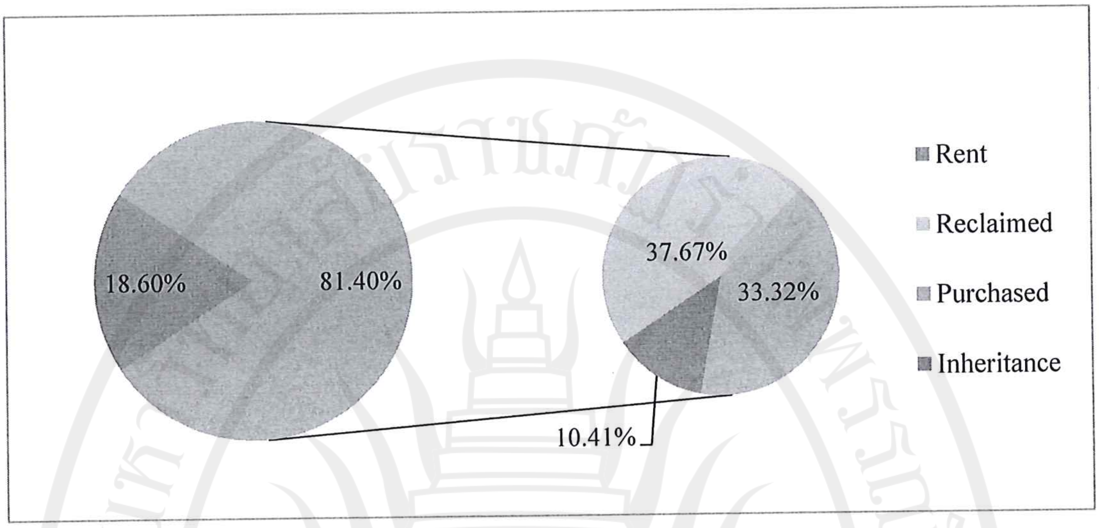


Figure 4.3 Sources of the land for the cassava households

4.2.4 Land size for cassava farming

The size of the farm plays a critical role for the sustainability in agriculture. This may have far-reaching consequences for the economy and the environment.

The result of the study in Battambang showed that the farmers have a land of 4.81 hectares on average while the farmers in Pailin province have only 3.75 hectares for cassava farming. Table 4.2 shows that the percentage of cassava farmers with 1-5 hectares of land is 71.67% in Battambang and 67.35% in Pailin, making Battambang farmers holding a bigger land. The average land holding size for the 2 provinces is 4.33 hectares per household in the study area. This is in correlation with the findings by the University of Battambang as part of the project funded by World Bank (2015) showing that the farmers have 5.32 hectares of cassava land in average, while their total holding land is 9.58 hectares.

4.2.5 Households size of cassava farmers

Labor is one of the catalysts that improve the productivity in agriculture. In the low-income countries, the working age represents 70% of the population. And agriculture represents the largest workforce sector at 59%. Among that sector, 52% are self-employed and 38% are engaged in unpaid (family) work (World Bank, 2018).

For this research, 74.3% of the household size ranged from 4 to 6 people. And most of the respondents have family members working on their own farm which could serve as a source of cheap labor to the farmers. This corresponds to Osuji et al (2014).

4.2.6 Farming experiences of cassava farmers

The farmers in Battambang have been growing cassava for a longer time than the farmers in Pailin. 66.67% of the farmers in Battambang province have grown cassava for 5 to 15 years while 46.94% of the farmers in Pailin province have grown cassava for less than 4 years. At the same time, 63.3% of all the farmers in this study had more than 5 years of experience in cassava cultivation as shown in Table 4.4.

The farmers have acquired enough farming experience that can give them an opportunity to use the new farming techniques more effectively. They are willing to adopt sustainable conservation practices that can make a meaningful and real impact on agricultural production (Ejike & Osuji, 2013; Osuji et al., 2014). Furthermore, experienced farmers who belong to a farmer's associations, who relatively have access to markets, who sold cassava to processors, and who planted cassava as sole crop, those achieved a higher level of technical efficiency in cassava production in Uganda (Abass et al., 2016). Our results in Battambang and Pailin indicated that the farmers with enough experience (8 years), and with basic knowledge of cassava farming, those accept to use new varieties with a very high yield potential.

Table 4.2 Land size of cassava farming

Items		Provinces				Total		Average
		Battambang		Pailin				
		Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	
Land size	0.5 – 1 hectare	1	1.67	6	12.24	7	6.42	4.33 Hectares
	> 1- 5 hectares	43	71.67	33	67.35	76	69.73	
	> 5 – 10 hectares	11	18.33	8	16.33	19	17.43	
	> 10 hectares	5	8.33	2	4.08	7	6.42	
	Total	**60**	**100**	**49**	**100**	**109**	**100**	
	Average	**4.81 hectares**		**3.75 hectares**		-	-	

Table 4.3 Households size of cassava farmers

Items		Provinces				Frequency	Percentage	Average
		Battambang		Pailin				
		Frequency	Percentage	Frequency	Percentage			
Household size	2- 3 person	9	15	10	20.41	19	17.43	4.6 person
	4- 6 person	43	71.67	38	77.55	81	74.31	
	7 person and above	8	13.33	1	2.04	9	8.26	
	Total	**60**	**100**	**49**	**100**	**109**	**100**	
	Average	**4.88 person**		**4.26 person**		-	-	

Table 4.4 Farming experiences of cassava farmers

Items		Provinces				Frequency	Percentage	Average
		Battambang		Pailin				
		Frequency	Percentage	Frequency	Percentage			
Farming experiences	1-5 Years	17	28.33	23	46.94	40	36.7	8 years
	5- 10 Years	33	55	11	22.45	44	40.37	
	10-15 Years	7	11.67	12	24.49	19	17.43	
	Above 15 Years	3	5	3	6.12	6	5.5	
	Total	**60**	**100**	**49**	**100**	**109**	**100**	
	Average	**3 years**		**5 years**		-	-	

4.3 Agricultural practices of cassava farmers

4.3.1 Land preparing

A good technique of land preparation is always necessary in order to achieve a successful cassava plantation. Although cassava can grow well on poor soil with limited fertilizer, a well-prepared field with weed control, recycled plant nutrients and a good soft soil will result in an optimal cassava crop. One or two times of plowing is usually implemented by cassava growers. Land is ploughed or dug properly for loosening soil to a depth of 20 to 25 cm.

This research shows that 83.33% of the farmers in Battambang and 67.35% of the farmers in Pailin plow their field twice per crop. This study also shows that 10% of cassava farmers in Battambang and 12.24% in Pailin don't plow their field, because their farm is mostly on a hill as shown in Figure 4.4. So, we can deduct that most of the cassava farm land is plowed.

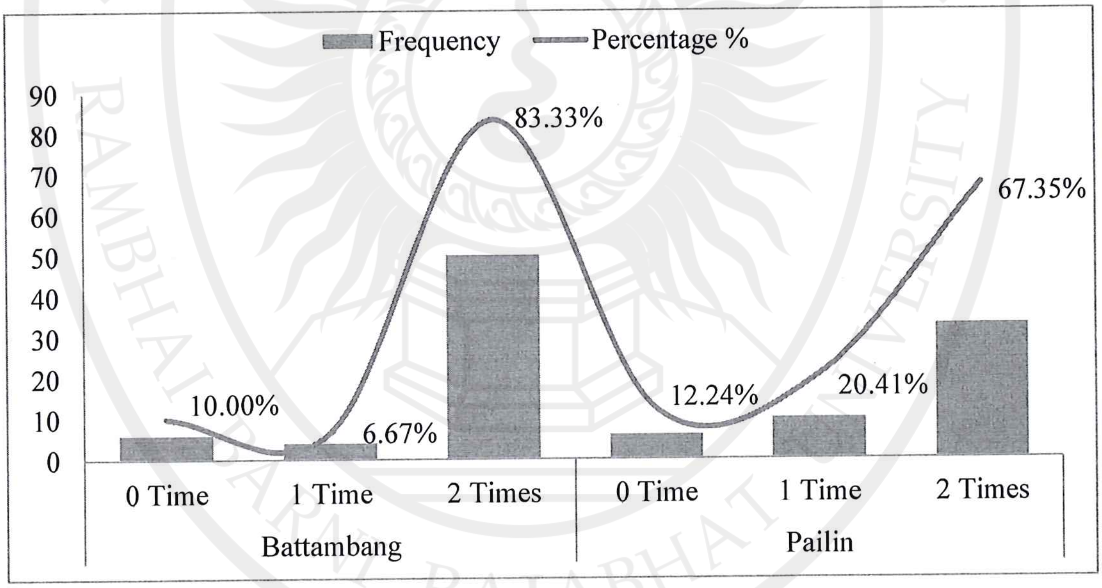


Figure 4.4 Frequency and percentage of plowing on cassava farms

4.3.2 Land use

From this research, it can be concluded that, the farmers have an average farming area of 7.63 hectares, which includes a cultivated area of 58% cassava, 30% maize, 6.11% rice, 5.86% of other fruits such as mangos, longans, cashew nuts. So, cassava is the most important crop in this study area, and also a major income.

This portion of the land, 58% for cassava plantation, was previously used in rotation for planting maize on 43.66% of the surface and most farmers planted cassava as a mono-crop; only a few farmers were growing cassava as a mixed crop. The rotation crop is the best way for cassava famers to increase the soil nutrients, improve the soil structure and the water holding capacity. As a result; it would reduce the pest and lower the risk for diseases. Ball et al (2005) revealed that the rotations in current practice have influenced yield nutrient cycling and disease suppression. The crop rotation will also favor the development and distribution of biopores and the dynamics of microbial communities. These processes contribute to the development of soil structure.

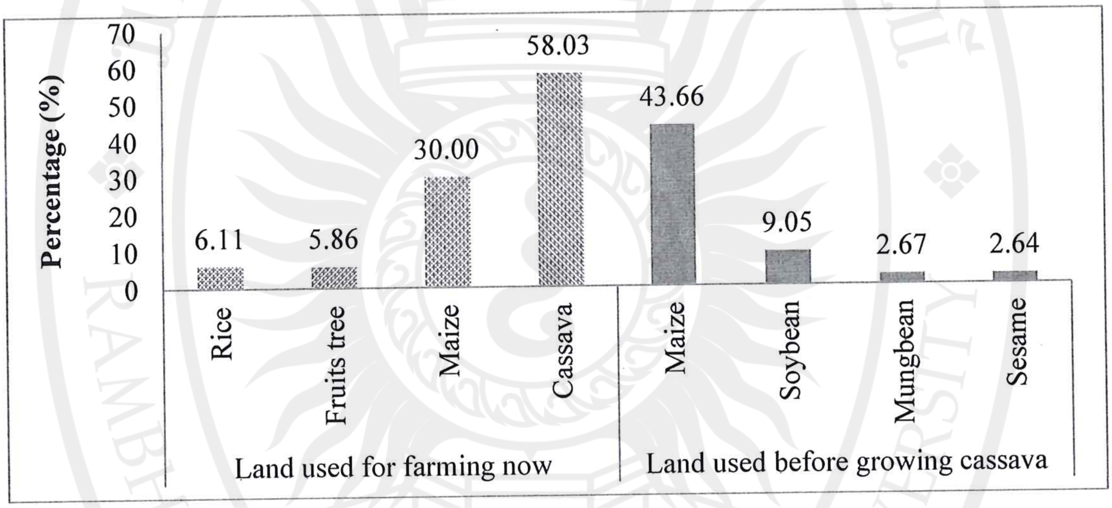


Figure 4.5 Land used for cassava farming in both provinces

4.3.3 Cassava varieties

In Battambang province, the most popular variety is Rayong 9 while variety 89 is the favorite in Pailin province. More than 43.12% of the farmers in Battambang planted Rayong 9 variety and 17.43% planted the variety 89. Also, 8.26% planted an unknown variety as shown in Figure 4.6. Among these cassava varieties, Rayong 9, Hay Boung 60 and KU 50, are from Thailand (Howeler & Ceballos, 2018). Kromumyun variety is from Vietnam, while the 89 and KorTorl varieties are from an unknown source, although the owner of silo mentioned that those come from Thailand. Rayong 9, KorTorl, Hay Boung 60 and KU 50 have high yield potential and high starch content while variety 89 has a very high yield potential. These varieties were introduced by the local silos and Thai traders; because they have high starch content and they are appropriate to make Bio-ethanol and animal food.

The farmers use different cassava varieties, but they do not know which variety is suitable for their specific agro-ecological condition. At present time, no cassava breeding program has been either established or carried out in Cambodia, besides some testing of some varieties from cassava breeding centers of Thailand, Vietnam, and China (MAFF, 2015). It is undeniable that the cassava farmers have a difficulty to find or to accept a healthy and high-quality planting material.

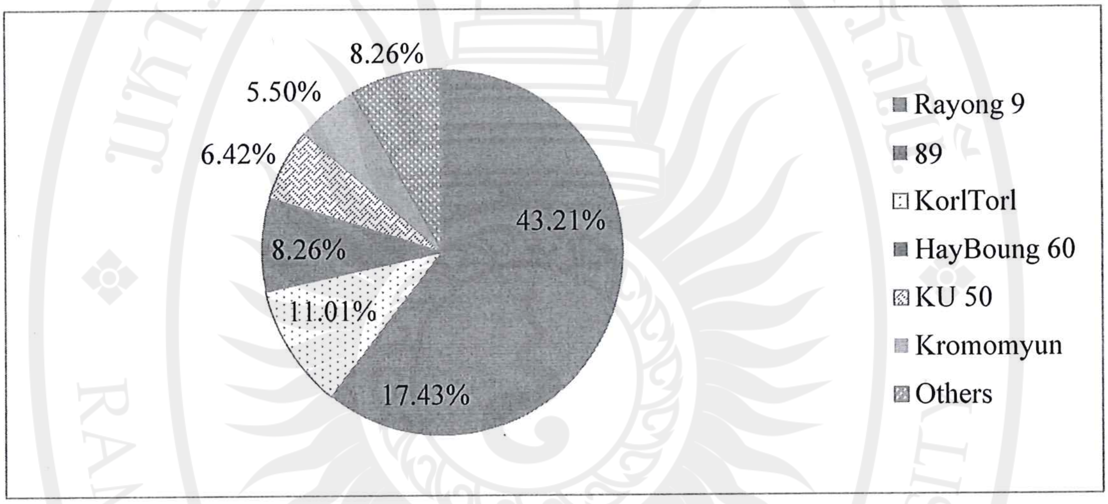


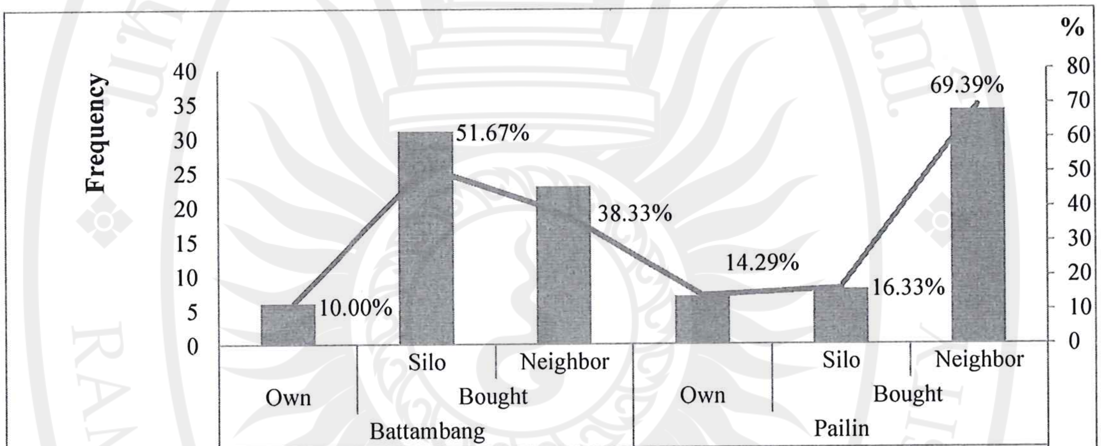
Figure 4.6 Varieties of cassava in study area

4.3.4 Source of cassava stems

The best quality for the planting material is usually taken from the middle two third of the stem of the plants that are 10-12 months old. The stakes are about 20-25 cm long and have between five to seven nodes (MAFF, 2015).

After harvesting, most of the cassava farmers in both provinces will select the cassava stem to transplant in the next season. They keep some good varieties of cassava in their field between 1 to 3 months, until the rain comes, which means the time of the next plantation season. That is a rather long period of time to keep those selected cassava plants in the field, during the dry season. Consequently, a lot of that cassava dies in the field. So, the farmers have to buy some "Cassava stem" from another source. In Battambang, 51.67% of the farmers buy the cassava stem from the silo owners, and 38.33% buy from their neighbors. In Pailin, 16.33% of the farmers buy the cassava stem from the silo owners and 69.39% from their neighbors.

So we can deduct that only 10-14.29% of the farmers use their own "Cassava stem" for the next season planting, while 85.71%-90% have to buy the "Cassava stem" for their next season of planting. Our findings also revealed that most of the farmers bought or used cassava stem from a previous crop to plant a new crop. They say that it is very convenient, but unfortunately this technique provides an easy way for disease-causing pathogens, particularly viruses, to pass directly from one plant generation to another. The varieties not only need to respond to the requirements of the farmers but should have a resistance to diseases, which is of economic importance (one of the main reasons for production losses in cassava) (Martin et al., 2013).



	Battambang Own	Battambang Bought Silo	Battambang Bought Neighbor	Pailin Own	Pailin Bought Silo	Pailin Bought Neighbor
Frequency	6	31	23	7	8	34
Percentage	10.00	51.67	38.33	14.29	16.33	69.39

Figure 4.7 Frequency and percentage of cassava farming in both provinces

4.3.5 Method of planting

Depending on the growing conditions such as rainfall, flatness and soil types of the field, there are three planting methods used in cassava production. Those are horizontal method, inclined method and vertical method (MAFF, 2015).

The field research in both provinces showed that 100% of the planting method is vertical method. Half of the stake (5-8 cm) is inserted into the ground. The distance between the plants is 40-50 cm. The distance between the rows is 100-150 cm and the high of the ridge is 50 cm. Thus, the plant density of 13,083-19,642 plants per hectare. But for a good yield of cassava, the farmers should have a density of 10,000-15,000 plants per hectare (MAFF, 2015). The mostly of cassava famers stared to planting from February until May and start to harvesting from early January to March.

4.3.6 Fertilizer using

Cassava is known for its ability to grow in poor soils and to produce good yield where other crops fail. However, it is important to improve the nutrient availability of the soil, especially nitrogen (N) and phosphorus (P) particularly at the early growth stage as the root system of cassava develops slowly and has limited uptake (MAFF, 2015).

In the study areas, there are many misunderstandings among the farmers. In some cases, the information about cassava production is based more on myths than on facts. Some of those farmers often grow cassava with minimal or no fertilizer at all. Also, they would apply fertilizer, not for the cassava plant, but to improve the soil property only. They apply NPK (15-15-15) fertilizers or Bio-fertilizer only one 1 time or 50 kg per hectare when they raise bed before plantation.

Figure 4.8 shows that 58.33% of the cassava farmers in Battambang province used fertilizer in their farming, while in Pailin province, only 28.57% of the farmers used fertilizers. Thus, cassava farmers in Battambang used more fertilizer than the farmers in Pailin while the cassava farmers in Battambang unused fertilizers represented 41.67% and the farmers in Pailin were 71.43%.

Under continuous cropping, recycling and reusing of nutrients from organic sources may not be sufficient to sustain crop yields. Thus, the judicious use of chemical fertilizers is essential to maintain soil fertility. Fertilizer usage is closely associated with the growth phases of cassava. It should be made according to the following guidelines: first phase at 4 to 6 weeks after planting, the second phase, at 8-10 weeks after planting (MAFF, 2015). On the soils that are moderately deficient in P and K, a general recommendation is to use a fertilizer with an N: P: K ratio of roughly 1:1:2, e.g. 40-80 kg N, 40-80 kg P and 80 -160 kg K per ha (MAFF, 2015).

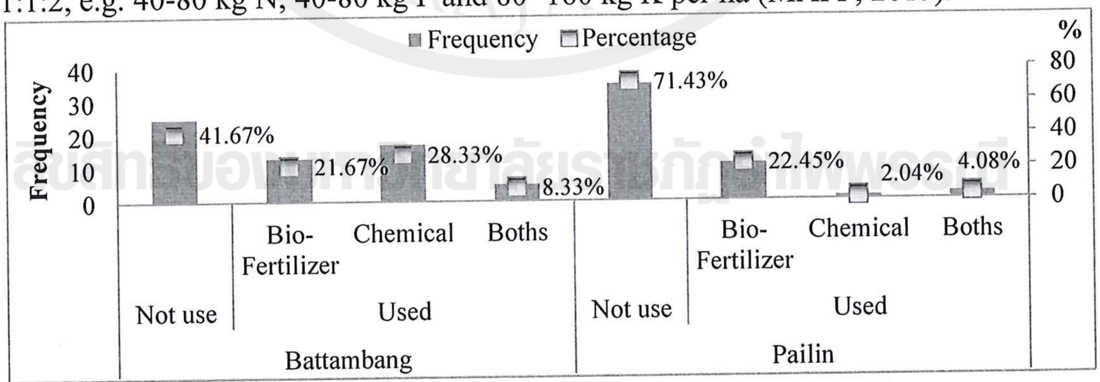


Figure 4.8 Frequency and percentage of fertilizers usage by cassava farmers

Liquid fertilizer (called Chy Tuek or Hormone in the local language) is the most widely used. Cassava farmers we interviewed believe that it improves the cassava yield. One month after planting, the farmers always spray the leaves of the plants with the liquid fertilizer for the first time. The second time of spraying was always conducted 2 to 4 weeks after the first time of spraying. But the rainfall will have an influence on the frequency of spraying.

The frequency of spraying and the percentage of farmers who do the spraying are explained as follow:

In Battambang: 70% of the farmers sprayed 1 time, 15% sprayed 2 times, and 15% did not spray at all. In Palin, 93.88% of the farmers sprayed 1 time, 2.04% sprayed 2 times, and 4.08% did not spray at all as shown in Figure 4.9. So, we can conclude that the majority of the cassava farmers used the liquid fertilizers (85% - 95.92%) and the dry fertilizers (58.33%-28.57% of them).

A similar study in Cambodia revealed that only 10 out of 45 sampled households applied fertilizers to their cassava crop. Application rates were low at 0 to 7 kg N/ha, 0 to 11 kg P_2O_5/ha, and no fertilizer K (Sopheap et al., 2012).

Our finding cassava farmers usage fertilizer not right or not based on cassava do need. However, it improves the cassava yield in the study area. To improve the yield on cassava farmers should be followed this concept the 4R Nutrient Stewardship concept of applying the right source of plant nutrients at the right rate, at the right time, and in the right place. IPNI (2012) provides guidelines on fertilizer management that will help farmers reap the full benefits of their investment in fertilizer.

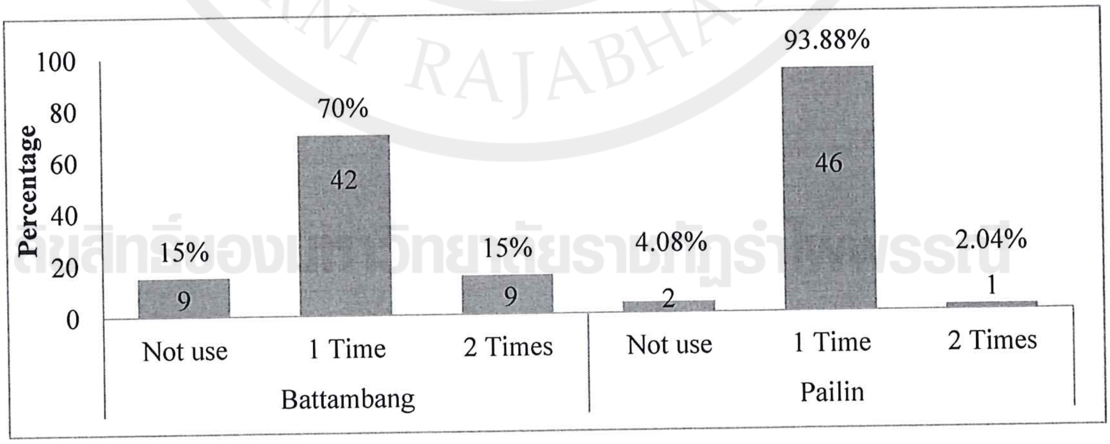


Figure 4.9 Frequency and percentage of liquid fertilizer used by cassava farmers

4.3.7 Weed controlling

Weed control is a very important factor that improves yield; a very good weed control could increase the yield by 7 to 8% according to a previous study (Clair et al., 2000). In the study area, the cassava farmers conduct two types of weed control. First, the weed is removed by hand when the cassava is 1 month old and trimming is done before harvesting, at 2-3 months. The second method is using herbicides.

The herbicides used are produced in Thailand: 48% of Glyphosates and 28% of Paraquate are mostly used in the study area to weed control. This usage corresponds to the recommendation of the Ministry of Agriculture, Forestry, and Fishery (MAFF, 2015). However, because the study area is close to the Thai border, the cassava farmers mostly bought herbicides or chemical pesticides from Thailand and they could not read or understand how to use it.

Figure 4.10 shows that the cassava farmers in Battambang province did a weed control with herbicide 2 times (15%), 3 times (33.33%), 4 times (30%), 5 times (15%) and 6 times (6.67%), in their cassava farming. In Pailin province, the farmers did a weed control with herbicide 2 times (6.67%), 3 times (73.47%), and 4 times, which requires 4.08% of their work time.

The result of our finding, the majority of cassava farmers used the herbicide based suggestion of farmers or suggestion by input suppliers rather than following the recommendations of agricultural experts. If farmers followed the expert's recommendation, they will get a benefit and don't expenditure money and time a lot with herbicide spraying.

The recommendation of experts regarding herbicide application to cassava is as follows: First Application: apply a pre-emergence herbicide, for example, 1,500-2,250 g ai/ha of metolachlor 40% EC or 750-1,500 g ai/ha of diuron 80% WP directly after planting and before germination occurs. Then, this will control weeds for 30-45 days. Second and third application: apply a post-emergence herbicide such as 500-750g ai/ha of paraquat 27.6% AS or 1,500 g ai/ha of glyphosate 48% AS, when and where it might be necessary (MAFF, 2015).

At the same time, the manual weed control (hand weeding) in Battambang province was done 1 time and it represented 53.33% of their work time for the cassava farming. In Pailin province, the hand weeding was done 1 to 3 times and it represented

96% of their work time. So, we can understand the reason why the cassava farmers in these 2 provinces prefer to use herbicides for weed control.

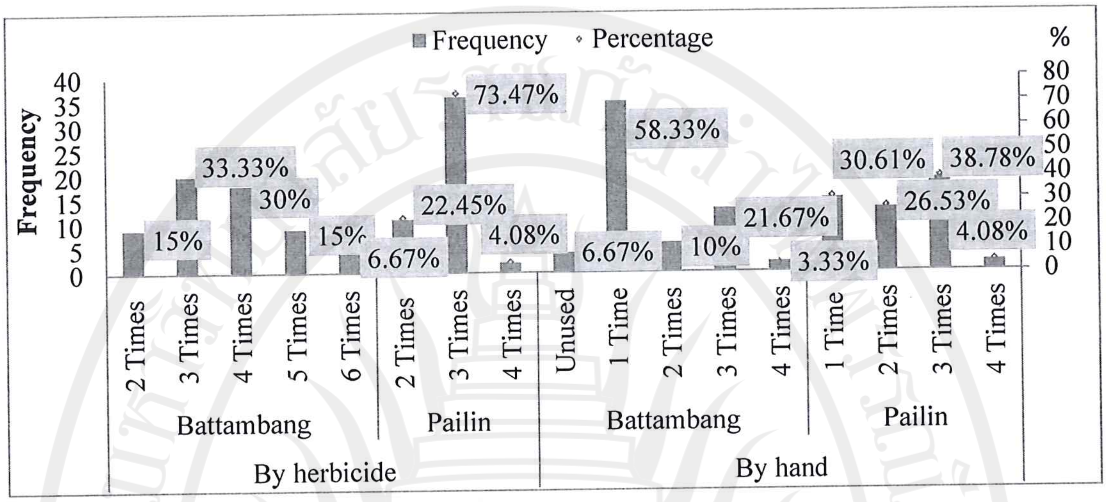


Figure 4.10 The ways of controlling weed by cassava farmers

4.3.8 Pesticide usage

In the past, cassava growing areas have been relatively free of pest and disease. Evidence now indicates that the pest problem is compounded by the overlapping of cassava crops. The main pests in South East Asia are mealybug mite and whitefly. The mealybug and mite attacks the cassava at the age of 3 to 6 months. The result is a yield loss of 20 to 40%. The yield loss due to the whitefly can be up to 79% (MAFF, 2015; Ignazio et al., 2016).

The whitefly is a global pest for cassava, harming the plant by direct feeding, facilitating a sooty mold fungus on the leaves, and transmission of pathogens, such as the Cassava Mosaic Virus (CMV) that yielded record losses of up to 82% in Africa, India and Sri Lanka (Ignazio et al., 2016). Moreover, in Southeast Asia, we don't know yet all the impact of CMV. However, Cambodian and Vietnamese authorities have officially reported the presence of CMV in seven provinces in eastern and central Cambodia, and ten provinces in southern Vietnam (CIAT, 2015).

Figure 4.11 show that 50% of cassava farmers in Battambang had used insecticides as compared to 24.48% for the farmers in Pailin. The majority of invasive insects are mite and mealybug in the study area. This situation conforms to MAFF (2015) and Ignazio et al (2016), which show that the main pests in South East Asia are the mealybug mite and the whitefly.

In Battambang province, the percentages of farmers who used insecticides are as follows: 1 time for 11.67%, 2 times for 21.66%, 3 times for 16.67%. In Pailin province, they used insecticides as follows: 1 and 2 times presented the same for 10.20%, 3 times for 4.08%. Based on our interviews, cassava farmers often used pesticides based on their experience and suggestion of other cassava farmers or sellers agrochemicals, instead of the manufacturer's recommendations. And the farmers would often have mixed pesticide with chemical fertilizers to spay.

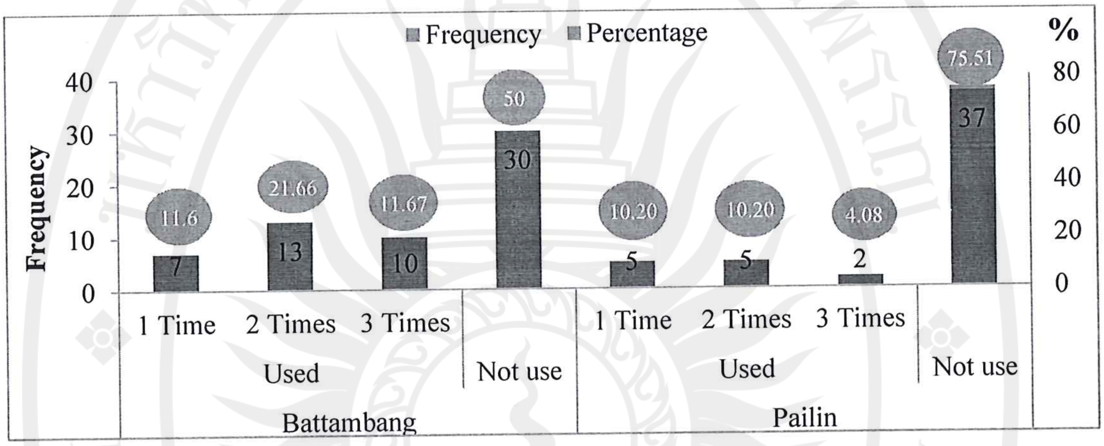


Figure 4.11 Ways of pest control of cassava farmers

4.4 Cassava yield of cassava farmers

4.4.1 Cassava yield

The cassava farmers can do their harvesting after 10 months. In this study, the data from this analysis points out that, for Battambang province, the yield of fresh roots was a maximum of 38 tons per hectare and a minimum of 4 tons per hectare. The highest frequency represented 18 tons per hectare (10%) and the mean yield was 19.45 tons per hectare. In Pailin, the maximum and the minimum yields per hectare were the same as in Battambang while the highest frequency represented 30 tons per hectare (14.29%) and the mean yield was 25.39 tons per hectare (Table 4.5).

The yield of less than 4 tons per hectare was due to a drought in some areas. Moreover, the low fertility of the land and the use of poor quality cassava varieties also contributed to low productivity. So, the average yield of fresh root cassava in the study area was at 24.16 tons per hectare and this yield is in line with

FAOSTAT (2017). In an optimal growing environment, the yield of cassava could reach 90 tons per hectare (El-Sharkawy, 2004).

So, we can deduct that the average yield of fresh root cassava in Pailin is higher than the average yield in Battambang. Pailin province has a better rainfall and a better soil. These cassava farmers mostly used the new variety of high yielding (89), while the cassava farmers in Battambang mostly used the variety Rayong 9.

Table 4.5 Distribution of fresh roots and dried chips of cassava

Battambang				Pailin			
Yields[1/] (t ha^{-1})	Frequency	Percentage	Cumulative %	Yields[1/] (t ha^{-1})	Frequency	Percentage	Cumulative %
4	1	1.67	1.67	4	1	2.04	2.04
6	1	1.67	3.33	10	1	2.04	4.08
8	2	3.33	6.67	11	1	2.04	6.12
9	1	1.67	8.33	15	1	2.04	8.16
10	3	5	13.33	17	2	4.08	12.24
11	1	1.67	15	18	2	4.08	16.33
12	2	3.33	18.33	19	2	4.08	20.41
13	4	6.67	25	20	4	8.16	28.57
14	2	3.33	28.33	21	2	4.08	32.65
15	5	8.33	36.67	22	2	4.08	36.73
16	3	5	41.67	24	1	2.04	38.78
17	1	1.67	43.33	25	3	6.12	44.90
18	6	10	53.33	26	1	2.04	46.94
19	2	3.33	56.67	27	3	6.12	53.06
20	2	3.33	60	28	3	6.12	59.18
21	2	3.33	63.33	29	1	2.04	61.22
22	2	3.33	66.67	30	7	14.29	75.51
23	3	5	71.67	31	2	4.08	79.59
24	4	6.67	78.33	32	3	6.12	85.71
26	4	6.67	85	33	3	6.12	91.84
30	1	1.67	86.67	35	2	4.08	95.92
32	3	5	91.67	36	1	2.04	97.96
34	1	1.67	93.33	38	1	2.04	100.00
36	3	5	98.33	-	-	-	-
38	1	1.67	100	-	-	-	-
Total	60	100		Total	49	100	
Mean = 19.45 Tons per hectare				**Mean = 25.39 Tons per hectare**			

1/ t ha^{-1} : Ton per hectare

4.4.2 Cassava yield gap

The yield gap is defined by the type of data used to represent the potential yield, the farmer's yield, and the procedures used to obtain these yields. Three categories of yield gap are generally recognized: (i) the gap between the theoretical potential yield and the highest research station yield; (ii) the gap between the highest research station yield and the highest farm yield; and (iii) the gap between the highest farm yield and the average farm yield (Tran, 2004; Lobell et al., 2009). The first category is the yield gap that scientists aim for varietal improvement. The second category usually reflects the differences in environmental conditions between research stations and farmers' fields which are non-transferable. The third category reflects physical and biological production constraints, e.g., soil fertility, water, crop variety, insect pests, diseases and weeds, together with socio-economic constraints, e.g., production costs, credit availability, inputs, labor and knowledge (Tran, 2004). This third category of yield gap is of special interest for practical purposes, as it has the potential to be reduced through improvements in crop management or access to inputs

In the study area, the yield of fresh root cassava showed a great variation, ranging from 10 to 34 tons per hectare, with an average of 22 tons per hectare. The yield gap between the maximum and the average yield was 12 tons per hectare, while the gap between the average and the minimum yield was 12 tons per hectare, giving a total gap between the maximum and minimum yield of 24 tons per hectare. These data are similar to the study of Sopheap et al (2012) which showed a large difference in the yield of cassava in Kampong Cham province, the difference between the high and low yield being 12.8 and 37.26 tons per hectare, respectively.

In the study area of Battambang and Pailin provinces, the yield values were distributed, with the moderately low group having the high frequency and declining towards both the higher and the lower ends. However, amount of the yield group (moderately high, moderately, and moderately low) presents small variations (Table 4.6). The mean yield of the moderately high to the low yield group ranged from 82.35% to 29.41% of the highest yield recorded, while the corresponding yield gap ranged from 6 to 24 tons per hectare. The maximum yield, 34 tons per hectare was considered to be representative of the maximum potential farm yield. The rainfall conditions and good management in agro-practices are impact to yield of cassava production in study area. However, some other experiments, run under Cambodian conditions, obtained the highest yield at 36 tons per hectare (Sopheap et al., 2008).

Luar et al (2018) revealed that the optimal nutrient management is a key to closing wide yield gaps and to attaining sustainable intensification in cassava. Continuous cropping of cassava without balanced fertilizer application can lead to soil nutrient depletion and yield decline over time. Fertilizer recommendations based on 4R principles are key to realizing the full benefits of fertilizer application in cassava.

Table 4.6 Distribution of yield group and yield gap for fresh root cassava

Yield group	Mean[1/] (t ha^{-1})	Range[1/] (t ha^{-1})	No. of fields	% of maximum yield	Yield gap[1/] (t ha^{-1})
High	34	> 30.99	18	100.00	-
Moderately high	28	26.00-30.99	22	82.35	6
Moderately	22	20.00-25.99	25	64.70	12
Moderately low	17	14.00-19.99	26	50.00	17
Low	10	<14.00	18	29.41	24

1/ t ha^{-1} : Ton per hectare

4.4.3 Factors affecting cassava yield

The following analysis was carried out to determine if there is a relation between the knowledge (education and farm experience) of the farmers, the yield of cassava, and the usage they make of agro-practice such as varieties, fertilizers, liquid fertilizers, pesticides, herbicides, and weed control (See Table 4.7, Model 1). The results showed that weed control, herbicides and liquid fertilizers were significant factors affecting the yield. Amount these agro-practices, weed control by hand has the largest positive effect on cassava yield. If cassava farmers increase the frequency of hand weed control by one, the cassava yield will increase by 6.4 tons per hectare. This is a factor of most importance for the agro-practice in cassava farming, in the study area. The second factor affecting yield is the usage of liquid fertilizers. If the farmers increase the frequency of spraying liquid fertilizers by one, the yield will increase by 2.75 tons per hectare. For the herbicides, there will be an increase of 1.12 tons per hectare if the farmers increase the frequency of application by one. All variables together accounted for 83% of the total yield variability (R^2 = 0.83) as shown in Table 4.7.

Model 2: Includes only the variables representing agro-practices and farm size. The data showed that R^2 increases by 1% if we compare with model 1; this means that agro-practices are the most important factors to determine the cassava yield, while the attributes of farmers including their knowledge do not have a significant influence on cassava yield.

Model 3: The knowledge of farmers might affect agro-practices adopted by the farmers and hence can have an indirect effect on cassava yield. To examine this possibility, Model 3, which include only the farm size and the attributes of the farmers, was also estimated. But the estimation result show that on variables including education level and farming experience has a significant association with cassava yield. This result implies that education and farming experience do not have a significant correlation with agro-practices that effect cassava yield (Table 4.7).

Table 4.7 The regression analysis of the determinants of cassava yield

Variable	Model 1		Model 2		Model 3		Definition
	Coefficients	t-value	Coefficients	t-value	Coefficients	t-value	
(Constant)	4.644	1.095	5.035	1.377	17.665	4.342	-
Farm size	-.118	-1.195	-.121	-1.294	-.004	-.017	Planted area of cassava (ha)
[1]Gender	.029	.028	-	-	3.786	1.549	Gender of head household
Farm experience	.033	.488	-	-	-.169	-1.071	Years of cassava farming
[2]Education	-.069	-.195	-	-	.610	.717	Level of Education
Rayong 9	.809	.221	.654	.184	-	-	Dummy variable (Types of variety)
89	1.636	.438	1.551	.424	-	-	
KorlTorl	3.188	.847	3.082	.840	-	-	
HauyBoung 60	2.405	.634	2.300	.619	-	-	
KU 50	.211	.055	.014	.004	-	-	
Kromomyun	1.199	.304	1.023	.266	-	-	
Others	1.362	.358	1.225	.331	-	-	
Chemical fertilizers	1.045	1.008	1.039	1.019	-	-	Fertilizer usage of cassava farmers
Bio-fertilizers	-.390	-.494	-.400	-.516	-	-	Bio-Fertilizer usage of cassava farmers
Liquid fertilizers	2.758**	2.669	2.693**	2.682	-	-	Liquid fertilizers usage (Frequency)
Pesticides	-1.088	-1.303	-1.112	-1.355	-	-	Pest controlling by pesticides (Frequency)
Herbicides	1.120 **	2.913	1.125**	3.002	-	-	Weed controlling by herbicides (Frequency)
Weed controlling	6.405**	14.619	6.392**	14.839	-	-	Weed controlling by hand (Frequency)
Adjusted R^2		0.83		0.84		-0.002	-

**. Statistically significant at 1% level Sample (N) = 109 cassava farmers

[1](Male=1, Female=2)

[2](Score: 1= Illiterate, 2= Primary school, 3= Secondary school, 4= High school, 5= College

4.5 Sale prices of cassava

The study area was along the busy border of Cambodia-Thailand and the laws governing monetary management are limited; so monetary use is a bit more complicated, such as buying agricultural material, paid in Thai Baht. The workforce is paid in Khmer currency (KHR). Finally, converting both currencies to United Stated Dollars (USD), this is also used in Cambodia.

The study showed that 58 farmers out of 109 farmers produce fresh root cassava even though dried chip cassava brings a larger income and profit. This indicated that they have some difficulties in producing dried chips due to the lack of labor and they are faced with irregular rainfall.

Furthermore, processing cassava into dried chips at the farm level is an opportunity of employment for poor people, which is a growing problem in the region. Hence, both income and profits of the producers were higher for dried chips cassava than for fresh cassava since dried chips attract a higher price than fresh cassava, which is related to the findings of Hoa et al (2019).

4.5.1 Fresh root cassava

In Battambang, the maximum price was 2,300 BTH (70.72 USD) per ton, with a minimum price of 1,500 BTH (46.12 USD) and average price was 2,046.67 BTH (62.93 USD). In Pailin province the maximum price was 2,600 BTH (79.95 USD) per ton, with a minimum price of 1,500 BTH (46.12 USD) and average price was 1,985.26 BTH (61.04 USD) per ton (Table 4.8). This corroborates an average price similar to the price in Kanchanaburi province, Thailand (AFSIS, 2019).

4.5.2 Dried chip cassava

In Battambang, the maximum price was 6,000 THB (184.50 USD) per ton with a minimum price of 4,000 THB (123 USD) and the average price of 4,942.73 THB (151.99 USD) per ton. In Pailin province, the maximum price was 5,200 THB (159.90 USD) per ton with the minimum price of 4,200 THB (129.15 USD) and the mean price of 4,916.67 THB (151.18 USD) per ton (Table 4.8).

An earlier study shows that, in Thailand, in 2018, the price of the cassava chips was quoted at 233 USD per ton (FAO, 2018). This is higher than the average price in both provinces of Cambodia. Moreover, Cassava also lacks a developed food processing industry and also a lack of direct trade between the Cambodian cassava industries and the Chinese market. The Cassava depends on the markets of Thailand that fix their prices.

4.5.3 Prices gap for cassava farmers

The price of fresh root cassava showed a great variation, ranging from 2,600 THB (79.95 USD) to 1,785 BTH (54.88 USD) per ton with an average price of 2,001 THB (61.53 USD) per ton. The price gap between the maximum and the average price was 599 THB (18.41 USD) per ton, while the gap between the average and the minimum yield was 216 THB (6.64 USD) per ton, giving a total gap between the maximum and minimum price of 815 THB (25.06 USD) per ton (Table 4.9).

For the dried chips cassava, the price had a smaller variation than the fresh root cassava. The ranging was from 5,300 THB (162.97$) to 4,652 THB (143.05 USD) per ton with average price of 4,940 THB (151.90 USD) per ton. And the price gap between the maximum and the average price was 360 THB (11.07 USD) per ton (Table 4.9). This implies that the price gaps are influenced by the quality (starch content) of cassava, the irregular rainfall, the trader's competition, and involved period in harvesting.

Table 4.8 Distribution of sell prices of cassava farmers

Battambang						Pailin					
Fresh root value THB			**Dried chip value THB**			**Fresh root value THB**			**Dried chip value THB**		
Price[1/] (t^{-1})	Frequency	Cumulative (%)	Price[1/] (t^{-1})	Frequency	Cumulative (%)	Price[1/] (t^{-1})	Frequency	Cumulative (%)	Price[1/] (t^{-1})	Frequency	Cumulative (%)
1,500	1	6.67	4,000	1	2.22	1500	2	4.65	4200	1	16.67
1,700	2	20.00	4,300	1	4.44	1700	2	9.30	4800	1	33.33
1,800	1	26.67	4,500	1	6.67	1800	5	20.93	5000	1	50.00
2,000	2	40.00	4,623	1	8.89	1816	1	23.26	5100	1	66.67
2,100	1	46.67	4,700	1	11.11	1900	8	41.86	5200	2	100.00
2,150	1	53.33	4,800	3	17.78	1950	1	44.19	-	-	-
2,200	3	73.33	4,900	4	26.67	2000	11	69.77	-	-	-
2,250	1	80.00	5,000	30	93.33	2050	2	74.42	-	-	-
2,300	3	100.00	5,100	1	95.56	2200	8	93.02	-	-	-
-	-	-	5,200	1	97.78	2300	1	95.35	-	-	-
-	-	-	6,000	1	100.00	2400	1	97.67	-	-	-
-	-	-	-	-	-	2600	1	100.00	-	-	-
Total	**15**		**Total**	**45**		**Total**	**43**		**Total**	**6**	
Mean		**2,046.67**	**Mean**		**4,942.73**	**Mean**		**1,985.26**	**Mean**		**4,916.67**

1/ (t^{-1}) : Price per ton

Exchange rate: 1THB=123KHR 1$=32.52 THB (NBC, 2019)

Table 4.9 Distribution of price group and price gap of cassava farmers

Fresh root value THB						**Dried chip value THB**					
Price groups	Mean[1/] (t^{-1})	Range[1/] (t^{-1})	No. of Prices	% of maximum prices	Prices[1/] gap (t^{-1})	Price groups	Mean[1/] (t^{-1})	Range[1/] (t^{-1})	No. of Prices	% of maximum prices	Prices gap[1/] (t^{-1})
High	2,600	> 2,500	1	100.00	-	High	5,300	>5,000	37	100.00	-
Moderately	2,129	2,000-2,500	34	81.88	471	Moderately	4,652	4,000-5,000	14	87.77	648
Low	1,785	<2,000	23	68.65	815	Low	0	<4,000	0	0	0

1/ (t^{-1}): per ton

4.6 Capital of cassava farmers

The analysis was conducted by considering both the cash and imputed cost literally used by the farmers. The cash cost is a cost literally paid by the farmers in cash and as the wages paid for labor and service by fixed capital. The imputed cost is a cost not literally paid in cash but it is capital fixed as the production factors owned by the farmers such as household labor cost, service cost etc. The farmers are faced with a lack of capital in the cassava production. In the production stage, the farmers really need a big financial assistance for their cassava production to purchase the agricultural inputs and hire labor.

4.6.1 Capital source

In the production stage, the farmers are faced with a lack of capital and 58.72% of them take a loan as shown in the left pie chart of Figure 4.12. The right of pie chart of Figure 4.12 shown that the source of the loans 58.72% came from banks for 15.60%, from IMF for 34.86%, from input supply for 6.42%, and from personal relations for 1.83%. Thus, the Institutions of Microfinance (IMF) plays an important role in improving the cassava production in the study area with the monthly interest 1.5%.

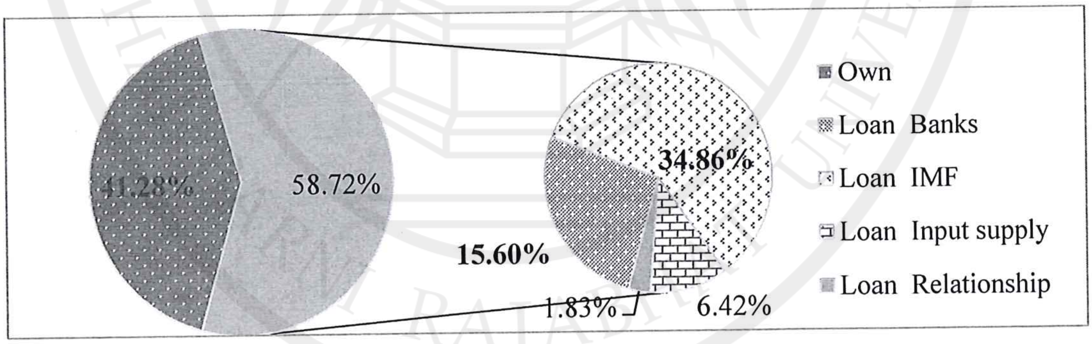


Figure 4.12 The capital sources of cassava farmers

4.6.2 Fixed cost analysis

The fixed cost includes the depreciation of the farm equipment's that would be used over one period of cassava farming. Table 4.10 shows the depreciation of the farm equipment: For the tractors, we divided the average price by 10% and then divided by the annual plowed performance of 100 hectares. Thus, the depreciation of the tractors per hectare was 15,299 KHR.

For the trucks we divided the average price by 20% and then divide the result by 450 tons where the average yield per hectare was 24.16 tons, so multiply by 24.16 tons. Thus, the depreciation of truck was 55,787 KHR.

Likewise, the depreciation of spray machines was 10,176 KHR and cutting machines was 4,075 KHR per hectare. Thus, the fixed cost per hectare of fresh root cassava production was 85,337 KHR (Table 4.10).

In case dried chip, the fixed cost per hectare was 52,795 KHR only, where average yield dried chip presented 10 tons per hectare. Hence, trucks were calculated by take average price (5,230,041 KHR) divided 20% and then divided 450 tons, and continue multiply 10 tons. Thus, the depreciation of truck with cassava fresh root was 23,245 KHR (Table 4.10).

Table 4.10 Distribution of depreciation in the fresh root cassava production

Items	Average price (KHR)	Depreciated (%)	Annual		Depreciated (h^{-1})	
			Depreciated	Variable used	Fresh	Dried
Tractors	15,299,083	10	1,529,908	100 hectares	15,299	15,299
Trucks	5,230,041	20	1,046,008	450 Tons	55,787	23,245
Spray machines	101,763	50	50,881	5 hectares	10,176	10,176
Cut machines	32,596	50	16,298	4 hectares	4,075	4,075
		Total			**85,337**	**52,795**

4.6.3 Cost production analysis on fresh root

The analysis for the cost of production is divided in two categories, which are the available cost and the fixed cost.

It was conducted by considering both the cash and non-cash cost literally used by the farmers. The cash cost is a cost literally paid by the farmers in cash and as a wage for labor. The non-cash cost is a cost not literally paid in cash but are assessed as production factors owned by the farmers such as household labor cost, stem cutting cost, etc.

The variable cost is divided into 3 parts: The first one is the intermediate input cost namely, stem cutting, fertilizers, herbicides, pesticides, plough, transportation, fuel, harvesting, etc. The second one is family labor and outside labor.

The third one is the interest cost that cassava famers pay for their loan at financial institutions.

The fixed costs include land rental fee and farm equipment depreciation. Land rental fee is calculated for an entire planting season both in cash and non-cash. In case of a land owned by farmer, it will be calculated as per land rental rate.

According to a study on cassava production cost with fresh root, it is found that the average cost of production per hectare of cassava fresh root is equal to 4,229,740 KHR (1,057.44 USD) which can be divided into cash cost of 2,768,871 KHR (692.21 USD), that is 65.46% of the total cost, and non-cash cost or assessed of 1,460,869 KHR (365.21 USD), that is 34.54% of the total cost.

In regards to variable and fixed cost, it is found that there is a variable cost of 3,288,335 KHR (822.08 USD) per hectare that is 77.74% of the total cost. One major factor of variable cost is the intermediate input from stem cutting until harvest by tractors, with a cost of 1,528,802 KHR (382.20 USD) per hectare, that is 36.14% of the total cost. The other major factor of variable cost is the labor cost with a total of 1,257,921 KHR (314.48 USD) per hectare, that is 29.74% of the total cost. And the last one is the cost of interest which was 501,612 KHR (125.4 USD) per hectare, that is 11.86% of the total cost.

In regard to fixed cost which consists of land rental fee and farm equipment depreciation cost, it is found that there is a fixed cost of 941,405 KHR (235.35 USD) per hectare that is 22.26% of the total cost shown in Table 4.11. However, the production cost per ton was lower than in Khanchanaburi province, Thailand.

While in the study area of Cambodia, the production cost per ton was 175,072 KHR (43.77 USD) in Khanchanaburi province of Thailand, it was 50 USD per ton (AFSIS, 2019). Likewise, the average yield was 24.16 tons, 4 tons per hectare higher than in Khanchanaburi.

The return on investment represented 1.40 Riel, meaning that for every 1 KHR or 1 USD invested in cassava farming, the farmer will get revenue of 0.40 KHR or 0.40 USD.

Table 4.11 Distribution of cost production of fresh root cassava

Items	Value HKR			Value USD	Percentages
	Cash	Assessed	Total	Total	
Variable cost	**2,562,093**	**726,242**	**3,288,335**	**822.08**	**77.74**
Stem cutting	225,914	128,183	354,097	88.52	8.37
Fertilizers	44,390	0	44,390	11.10	1.05
Liquid fertilizers	94,411	0	94,411	23.60	2.23
Herbicides	374,579	0	374,579	93.64	8.86
Pesticides	10,682	0	10,682	2.67	0.25
Plough	165,470	74,446	239,916	59.98	5.67
Bags	5,525	0	5,525	1.38	0.13
Link	743	0	743	0.19	0.02
Transportation	273,356	71,268	344,624	86.16	8.15
Fuel	35,643	0	35,643	8.91	0.84
Harvest by tractors	21,691	2,501	24,192	6.05	0.57
Planting labor	208,940	1,430	210,370	52.59	4.97
Fertilizing labor	3,721	1,075	4,796	1.20	0.11
Weeding labor	256,343	47,058	303,401	75.85	7.17
Herbicide labor	92,675	24,162	116,837	29.21	2.76
Spraying fertilizers	59,383	18,886	78,269	19.57	1.85
Pruning labor	33,465	11,673	45,138	11.28	1.07
Harvesting labor	438,917	60,193	499,110	124.78	11.80
Interest	216,245	285,367	501,612	125.40	11.86
Fixed cost	**206,778**	**734,627**	**941,405**	**235.35**	**22.26**
Land rental	206,778	652,291	859,069	214.77	20.31
Tractors	0	15,299	15,299	3.82	0.36
Trucks	0	52,787	52,787	13.20	1.25
Spray machines	0	10,176	10,176	2.54	0.24
Cut machines	0	4,074	4,074	1.02	0.10
Total cost per H	**2,768,871**	**1,460,869**	**4,229,740**	**1,057.44**	**100.00**
Total cost per T	**114,606**	**60,466**	**175,072**	**43.77**	
Average yield per H				**24.16 Tons**	
Average price per T			**246,123.00 KHR**	**61.53 USD**	
Return per H	**3,893,034**	**2,053,297**	**5,946,332**	**1,486.58**	
Net return per H	***1,124,163***	***592,428***	***1,716,592***	***429***	
Net return per T	**46,530**	**24,521**	**71,051**	**18**	
Return on investment 5,946,332 /4,229,740 = 1.40					

Exchange rate: 1 US$ = 4,000 Cambodia Riel (NBC, 2019)

4.6.4 Cost production analysis on cassava dried chip

In the study area, 51 out of the 109 cassava farmers produced dried chips. The process of drying the fresh root cassava by the farmers and transforming it to dried chips involves a weight loss of 53% to 57% depending on the degree of moisture and the starch content of each variety. The way to process cassava roots into dried chips, by the local workforce, is to slice the roots into chips size and let that dry in the sun for 3 to 5 days. It is found that the average cost of production per hectare of cassava dried chip is equal to 4,038,639 KHR (1,009.66 USD) which can be divided into a variable cost of 3,021,670 KHR (755.29 USD) per hectare that is 77.42% of the cost production. One major element of variable cost is the intermediate input, from stem cutting to loan interests, with a total of 1,484,815 KHR (371.20 USD), that is 39.37% of the total cost. The other major element is the expense for labor cost which was 1,536,855 KHR (384.21 USD), that is 38.05% of the total cost. It includes outside labor: 1,356,299 KHR (339.07 USD), that is 33.58% of the total cost, and family labor of 180,555 KHR (45.13 USD), that is 4.47% of the total cost. In regards to fixed cost, which consists of land rental fee and agricultural equipment depreciation, the total is 911,864 KHR (227.97 USD) per hectare which is 22.58% of the total cost, as shown in Figure 4.13.

The total cost also involved an amount of 782,422 KHR (195.61 USD) per hectare, or 78,242 KHR (19.56 USD) per ton, for harvesting, peeling and drying the fresh cassava. However, the cost production for peeling and drying was higher than the case of cassava value chain in Dak Lak Province, Vietnam. In the study area in Cambodia, it was 195.61 USD per hectare while it was 67 USD in Dak Lak province, Vietnam (Hoa et al., 2019). The difference in the cost maybe due to a larger usage of labor instead of machinery in Cambodia.

And the return on investment in study area, Cambodia represented 1,009.66/1,511.80 = 1.50, providing 17% more profit than the fresh cassava.

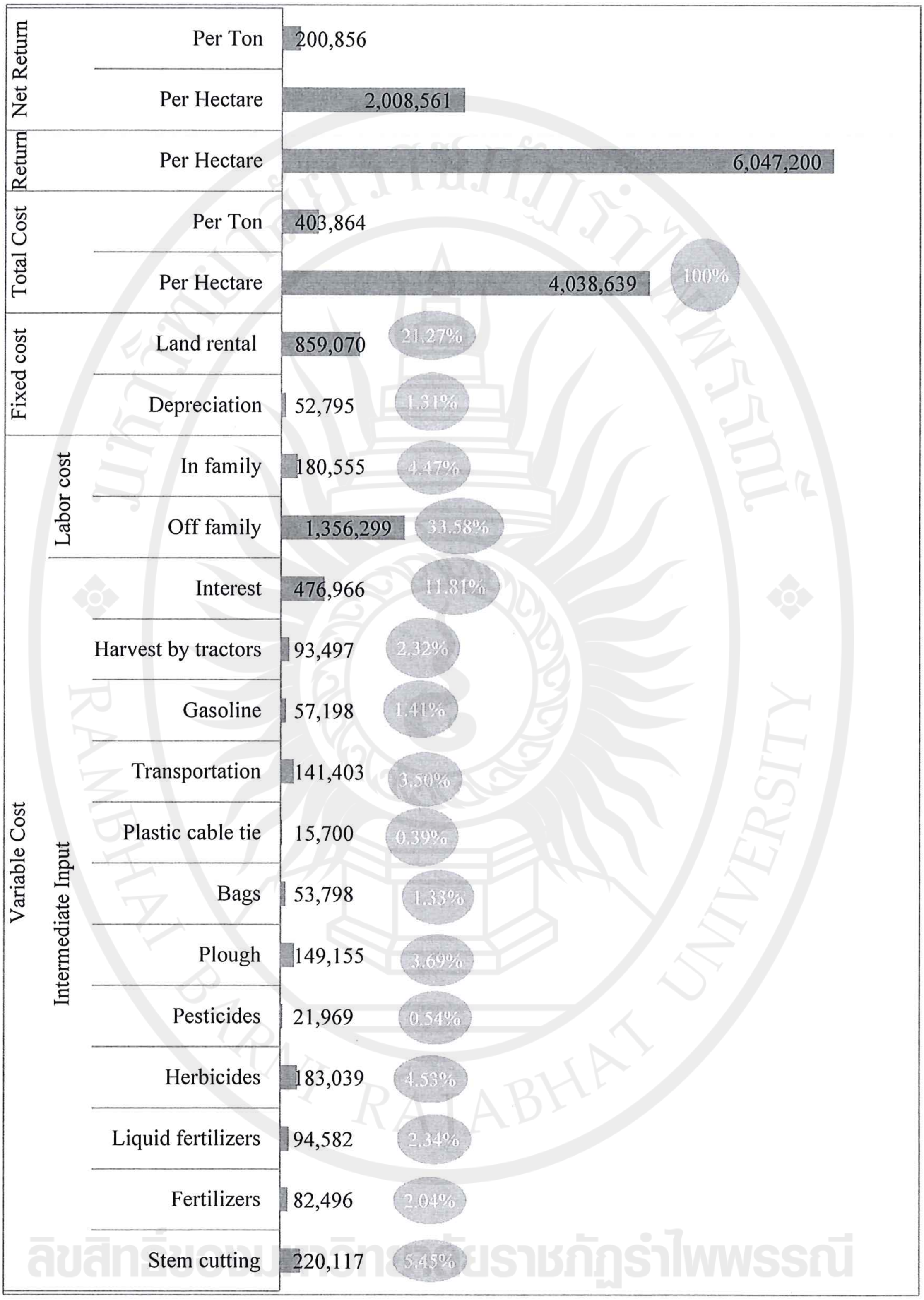


Figure 4.13 The structure cost production of dried chip's cassava farmers

4.6.5 Value add on cassava production

The analysis was conducted by considering both the cash and imputed cost literally used by the farmers. The cash cost is a cost literally paid by the farmers in cash as wages for labor and services by fixed capital. The imputed cost is a cost not literally paid in cash but it is capital fixed as the production factors owned by the farmers such as household labor cost, service cost etc.

For fresh root cassava, the total farmer's revenue was 5,946,331 KHR or 1,486.58 USD per hectare. The average price of cassava was 246,123 KHR (61.53 USD) per ton and the average yield was 24.16 tons per hectare. In the value chain analysis, the cost of intermediate inputs represented 15.47% of the total income of the producers. The highest percentage being the herbicides and stem cutting, at 6.3% (93.64 USD), and 5.95% (88.52 USD), respectively, of the total revenue. The expenditures for hired labor, hired service by fixed capital and land rental totalized 494.25 USD or 33.25% of the total revenue. The imputed cost for family labor and services by farmer's own fixed capital was 312.59 USD or 21.03% of the income. This confirms that cassava is a profitable crop, contributing to farmer's income, with an opportunity of employment for the poor people in rural areas.

The depreciation of the farm equipment such as tractors, trucks, equipment for spraying herbicides, weed cutters, represents an amount of 85,337 KHR (21.33 USD) per period of cassava farming. So, the total expenses, not including the imputed cost, was 745.59 USD or 50.16% of the total revenue. And the total cost of production was 1,058.19 USD or 71.18% of the total revenue. The net farm income was 773.03 USD or 52% of the total revenue and the net profit was 428.40 USD or 28.82% of the total revenue. This table shows that the farmers are sharing an imputed cost of 312.59 USD or 21.03% of the total revenue, while the net value added represents 83.09% of the total revenue.

Table 4.12 Major indicator analysis of fresh cassava per hectare

Items	Value		Proportion%
	KHR	USD	
Total Revenue (A)	**5,946,331**	**1,486.58**	**100%**
Intermediate Input (B)	**920,071**	**230.02**	**15.47**
Stem cutting	354,098	88.52	5.95
Fertilizers	44,390	11.1	0.75
Liquid fertilizers	94,411	23.6	1.59
Herbicides	374,579	93.64	6.3
Pesticides	10,682	2.67	0.18
Bags	5,525	1.38	0.09
Plastic cable tie	743	0.19	0.01
Fuel	35,643	8.91	0.6
Cash cost (C)	**1,976,984**	**494.25**	**33.25**
Transportation	273,356	68.34	4.6
Land preparation	165,470	41.37	2.78
Harvest by tractors	21,691	5.42	0.36
Labor cost	1,093,444	273.36	18.39
Interest	216,245	54.06	3.64
land rental fee	206,778	51.69	3.48
Imputed cost (D)	**1,250,359**	**312.59**	**21.03**
Transportation	71,269	17.82	1.2
Land preparation	74,446	18.61	1.25
Harvest by tractors	2,501	0.63	0.04
Labor cost	164,484	41.12	2.77
Interest	285,367	71.34	4.8
land rental fee	652,292	163.07	10.97
Depreciation (E)	**85,337**	**21.33**	**1.44**
Total expense (F = B+ C+E)	**2,982,392**	**745.59**	**50.16**
Total cost (G = F +D)	**4,232,751**	**1,058.19**	**71.18**
Net farm income (H = A-F)	**2,963,939**	**773.03**	**52**
Net profit (I = A-G)	**1,713,580**	**428.4**	**28.82**
Net value added (J = A- B -E)	**4,940,923**	**1,235.23**	**83.09**

1/: Exchange rate: 1 US$ = 4,000 Cambodia Riel (NBC, 2019)

2/: KHR: Khmer Riel (Currency Cambodia Riel)

For dried chips cassava production, the total profit was 4,232,751 KHR (1,511.80 USD) per hectare. The value added and the net profit accounted for 87.07% of the total production and 33.21% of the total revenue per hectare, as shown in Figure 4.14. As indicated by the left circle graph of Figure 4.14, the cost of intermediate inputs accounted for 12.05% of the total revenue, while depreciation and value added accounted for 0.87% and 87.07%, respectively. Peeling and drying fresh cassava cost 782,422 KHR (195.61 USD) per hectare or 78,242 KHR (19.56 USD) per ton, which accounted for 12.94% of the total revenue, providing 17% more profit than the fresh cassava.

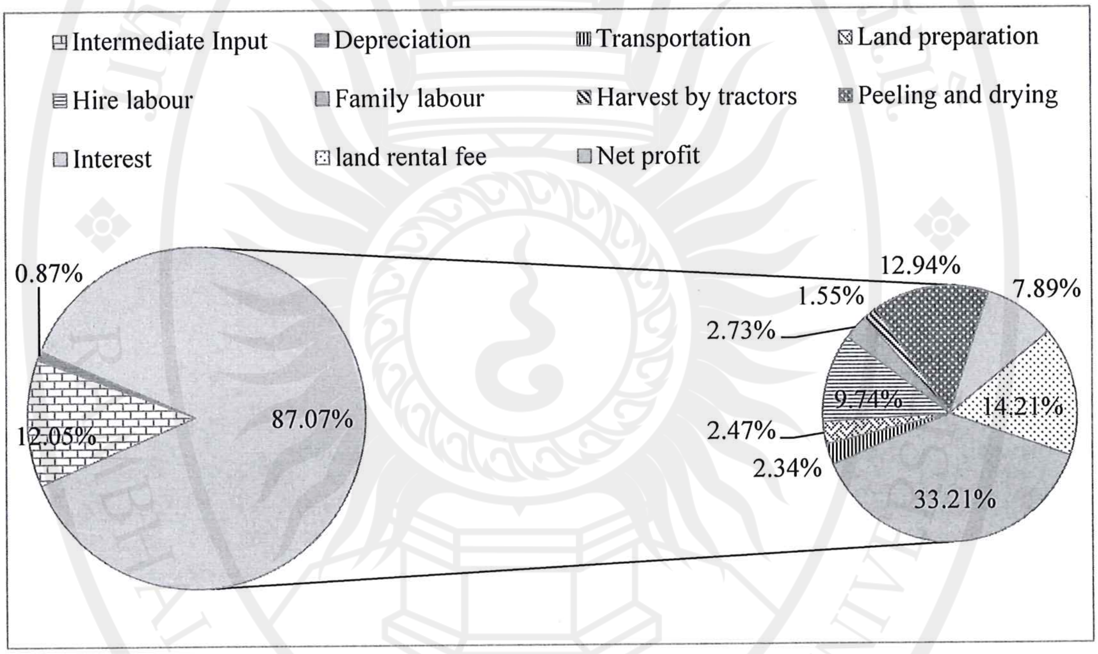


Figure 4.14 The proportion of each cost item to the total revenue

4.6.6 Breakeven point analysis on cassava production

The Breakeven point analysis is a useful tool to study the relationship between fixed costs, variable costs, and returns. A breakeven point tells us when an investment will generate a positive return and can be determined graphically or with simple mathematics. The Breakeven point analysis is divided in 2 types: the price (the sales prices vary but the total cost and yield per hectare is fixed); the other type is the yield (the yield changes due to unrelated factors: fertilizer, fuel, labor, etc.). But, the total cost per hectare and the price per ton are fixed items.

The analysis shown in Figure 4.15 (a) for fresh cassava production. So if farmers sell fresh cassava roots at a price below 43.79 USD per ton, they will have a loss in their cassava production. But if they sell it at a price higher than the breakeven price with a yield of 24.16 tons per hectare, they will gain a profit from their cassava production. Figure 4.15 (b) shows that the breakeven point yield was 17.19 tons with the total cost of 1,058.19 USD per hectare. So if the yield is lower than 17.19 tons per hectare, the farmers will have a loss in their cassava production. But if the yield is higher, they will get a profit.

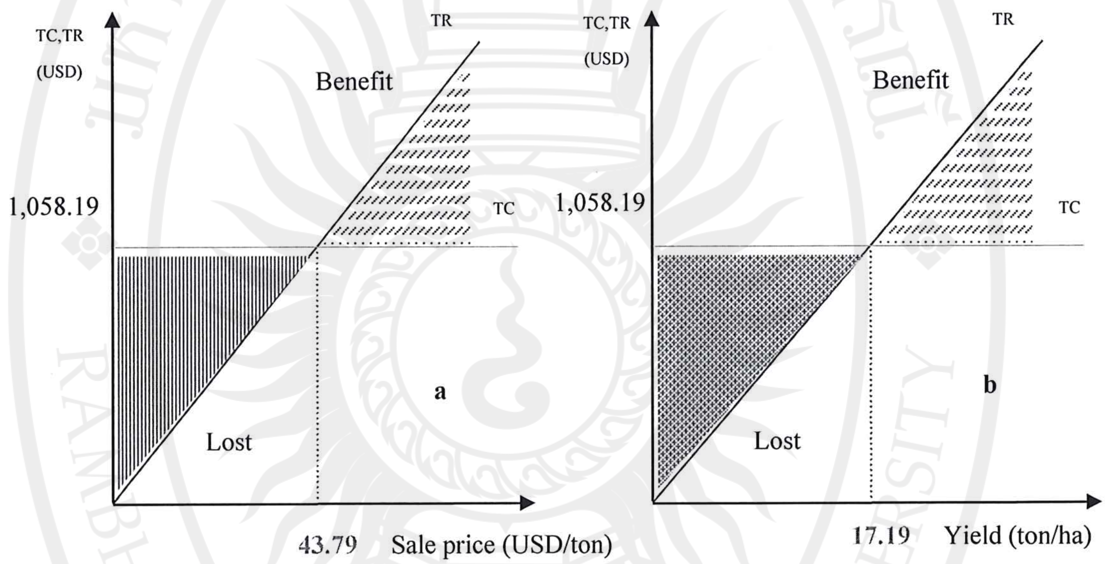


Figure 4.15 The breakeven point of fresh cassava production

In the case of cassava dried chips, the breakeven point price was 100.96 USD or 403,864 KHR per ton, with a total cost of 1,009.66 USD or 4,038,640 KHR per hectare. So, if the sales price is lower than the breakeven price, it will result in a loss in their cassava production. But, if the sales price is higher than the breakeven price with a yield of 10 tons per hectare, it will result in benefits for their production as shown in Figure 4.16 (a).

Figure 4.16 (b) shows that the breakeven point of yield was 6.67 tons per hectare. So if the yield is lower than 6.67 tons per hectare, the farmers will have a loss in their cassava production. But if the yield is higher than the breakeven point, the farmers will gain a profit from their cassava production.

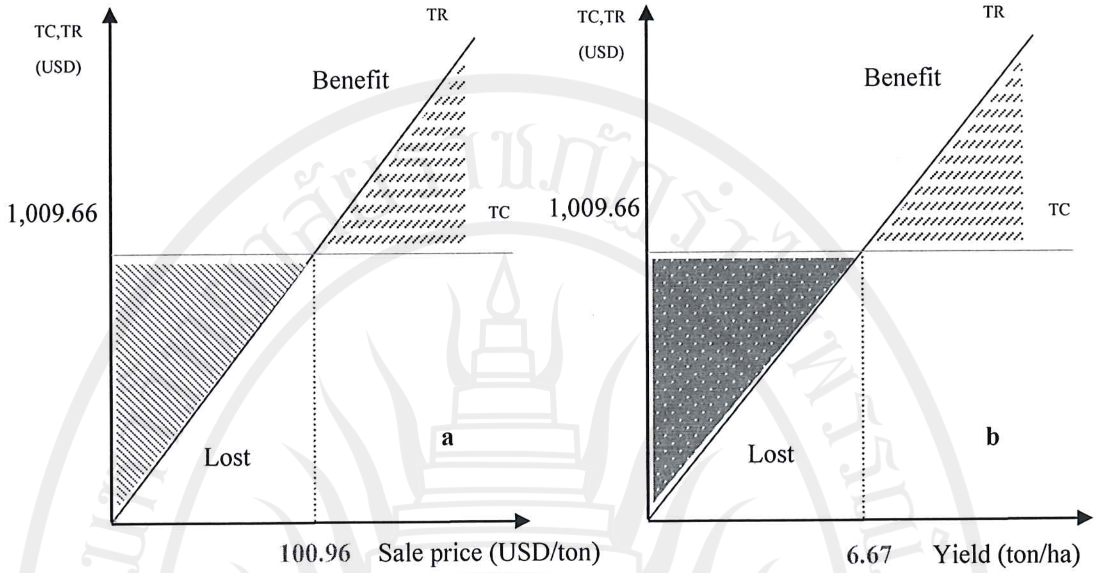


Figure 4.16 The breakeven point of dried chip cassava production

Around 24% of the fresh root cassava farmers achieved a yield that is lower than the breakeven point, but none of them sold their fresh root cassava below the breakeven price. So, it is deducted that about 24% of the fresh root cassava farmers faced a loss in their cassava yield production, partly due to the price fluctuation. This is not a big concern, though, because both groups of farmers, fresh roots and dried chips, sold their cassava higher than the breakeven price. It is not consistent with (MAFF, 2015); SNV Cambodia (2015) that revealed that there are serious concerns about the fluctuations of the price on the market due to lack of market information access and market uncertainty. And all local traders an processing enterprise owners rely on Thai and Vietnamese middlemen to set the price in the value chain of their location.

In the case of dried chips cassava, none of the farmers have experienced a yield or a sale price below the yield and price breakeven point. So, the farmers who produced fresh root cassava had a larger deficit than the ones who produced dried chips cassava. However, there is also a lack a developed processing industry - only 28.77% of cassava is processed locally and the rest is sent to Thai traders who export the cassava to the Chinese market. Hence, there is a significant loss of potential value added and this is not a sustainable market for Cambodia.

4.6.7 Value added of transporters

Since most of the farmers have a shortage of equipment during the harvest season, the transporters come to the rescue of the farmers this way: they group transportation and labor force to harvest the cassava and transport it to the silos. The payment for transportation varies between 80 THB (2.46 USD) to 200 THB (6.15 USD) per ton, depending on the road conditions and the distance between the field and the silo. On average, the farmers pay 142 THB (4.37 USD) per ton to the transporters.

So, the transporter will get an average revenue of 142 THB (4.37 USD) per ton from the farmer. From this revenue, transporters have to deduct 38.64 THB (1.19 USD) per ton for fuel and 5.26 THB (0.16 USD) per ton for telephone communication cost with the farmers and the workers.

At this stage, the value added for the transporters is 69%. It is less than the one of the farmers which is at 83% (fresh root cassava) and 87% (dried chips cassava). However, the large amount of cassava carried by the transporters gives them a higher profit than the farmers: Gross profit of 55.70 THB (1.71 USD) per ton and Net profit of 34.89 THB (1.07 USD) per ton.

On average, the transporters carry 2,500 tons of cassava per year. They are faced with many challenges: rainfall, variations in price due to possible delays in harvesting, bad road conditions between the fields and the silos. Addition, difficulty to mobilizer labor, because most of the labor forces migrate to Thailand.

Table 4.13 Major indicator analysis of the transporter chain per ton

Items	Value HTB	Value USD	Proportion
Output (A)	**142.00**	**4.37**	**100.00**
Intermédiate Input (B)	**43.90**	**1.35**	**30.89**
Fuel	38.64	1.19	27.19
Communication	5.26	0.16	3.70
Cash & Imputed Cost (C)	**42.40**	**1.30**	**29.84**
Driver	40.00	1.23	28.15
Annual tax	2.40	0.07	1.69
Depreciation of Truck (D)	**20.81**	**0.64**	**14.64**
Value Added (E = A-B)	**98.10**	**3.02**	**69.03**
Gross profit (F = E-C)	**55.70**	**1.71**	**39.19**
Net profit (G = F-D)	**34.89**	**1.07**	**24.55**

Exchange rate: 1 USD = 32.52 Thai Bath (NBC, 2019)

4.6.8 Value added of silos with the transformation dried chip

With the cassava value chain, Cambodia is considering to become the leader for cassava production and processing in Southeast Asia, together with Thailand. Cambodia is already among the 10 largest producers in the world, and if the current growth continues, it is likely to be among the largest 5 producers in the world and perhaps the largest producer in Asia (Goletti & Sin, 2016). To achieve this goal, the Royal Governance of Cambodia (RGC) has established a program to boost processing and export through the promotion of micro-enterprises, medium enterprises, and large processing enterprises. The Royal Government of Cambodia (RGC) offers a soft loan with low interest program to support the processing enterprises, as follow: For micro-enterprises: 50,000 USD; for medium enterprises: 250,000-500,000 USD, and for large enterprises: more than 500,000 USD (MIH, 2014). However, the majority of the silo enterprises do not qualify for that soft loan because of the complexity of the admission criteria. The silo owners claim that one of the criteria is to have storage of dried chips cassava of equal value to the requested loan. They find that criteria inappropriate to their need. So, all the silos accept a loan from the banks or the microfinance, where it is easy to obtain.

The silos bought the fresh root cassava from the farmers and then processed it to dried chips cassava. The average price of fresh root that silos bought from farmers was 2,001 THB (61.53 USD) per ton. Then, they sell the processed dried chips cassava to CP animal company and Thai traders at the average price of 6,225 THB (191 USD) per ton. However, the processing of 1 ton of fresh root into dried chips is only 0.45 ton on average.

The analysis of the financial situation from the silo perspective, shown in Table 4.15, indicates that the amount spent by the silos for intermediate input to process fresh cassava was 67.22 USD per ton, which represents 78.03% of their total production cost. That amount is hereby detailed: 71.43 % for the cost of buying fresh root cassava from the farmers, 3.57% for transportation, 1.16% for telephone communications, and 1.87% for fuel.

At this stage, the added value for the silos is 21.97%, which is much less than the farmers with dried chips cassava, at 87.07%. However, due to the very large amount of cassava bought by the silos, they have a higher profit than the farmers, namely: Gross profit of 578.88 THB (17.80 USD) per ton; Net profit of 398.81 THB (12.26 USD) per ton. The quality of cassava tubers deteriorates depending on the harvesting season, the length of cultivation, and the variety types. This represents 80 to 90% of the purchase price, depending on the time after harvesting and the moisture content of the cassava. On average, the silos buy 15,500 tons of fresh root cassava and processing it to dried chips; they have 7,000 tons left, annually.

Moreover, the silos are usually faced with a lack of capital to buy cassava at harvest time. The silos played a vital role in the cassava value chain and their demand has led to the enhancement of the value of cassava roots, which is transformed into dried chips. And then, the storage continues for 3- 6 months before 67% or more of it is sold to the Thai traders; the rest is sold locally (CP Company).

Table 4.14 Major indicator analysis of fresh cassava (1 ton) to dried chips

Items	**Value HTB**	**Value USD**	**Proportion**
Output (A)	**2,801.25**	**86.14**	**100**
Intermediate Input (B)	**2,185.88**	**67.22**	**78.03**
Fresh root	2,001.00	61.53	71.43
Transportation	100.00	3.08	3.57
Communication	32.52	1.00	1.16
Fuel	52.36	1.61	1.87
Cash & Imputed Cost (C)	**36.49**	**1.12**	**1.30**
Salary/Wage labor	16.10	0.50	0.57
Interest	17.44	0.54	0.62
Annual tax	1.33	0.04	0.05
Monthly Tax	1.62	0.05	0.06
Depreciation (D)	180.07	5.54	6.43
Terrace	37.93	1.17	1.35
Machine cutting	6.61	0.20	0.24
Sensor	8.59	0.26	0.31
Truck	20.08	0.62	0.72
Automatic Scale	6.86	0.21	0.24
Storage	100.00	3.08	3.57
Value Added (E= A-B)	**615.37**	**18.92**	**21.97**
Gross profit (F= E- C)	**578.88**	**17.80**	**20.66**
Net profit (G= F-D)	**398.81**	**12.26**	**14.24**

Exchange rate: 1 USD = 32.52 Thai Bath (NBC, 2019)

4.6.9 Value added and gross profit sharing for the stakeholders

Figure 4.17 indicates how the value added is shared among the stakeholders comprising the farmers, the silos and the collectors/transporters, who obtain 64.24%, 25.22%, and 10.54% of the gross profits respectively. From these figures, we can see that the greatest value-added is created by the farmers, which is fair based on their contribution to the value chain among the stakeholders.

Shifting to cassava cultivation from other crops is considered an appropriate strategy in poverty alleviation for household farmers in the rural areas. In the cultivation phase, it is the farmers who, as the producers, gather almost all the resources required to produce fresh and dried chips cassava. These findings are also similar to the study Hoa et al (2019) which quantifies the percentage of the actors as follow: the farmers 38%, the ethanol factories 28%, the starch factories 27%, the collectors 4% and the traders 3%.

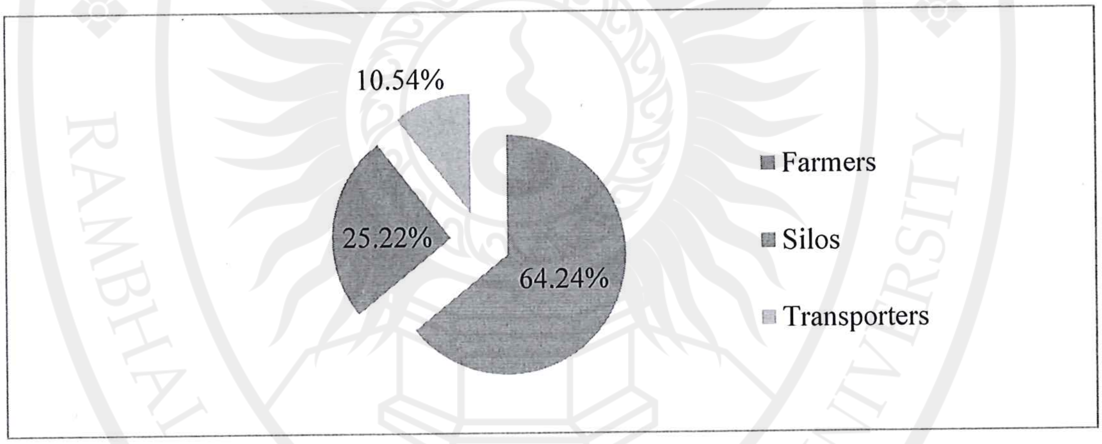


Figure 4.17 The percentage of value added shared among the stakeholders

The gross revenue expresses an economic gain or loss for an actor, once all the current production costs have been met. We can see that the silos and the transporters have lower gross revenue per ton than the farmers, as shown in Figure 4.18. However, if we do the calculation that covers one period of cassava production, then the collectors/transporters and traders benefit of higher gross revenue compared to the farmers. This can be explained by a much higher volume of their transactions than the volume of the farmers. This corroborates with the findings of Hoa et al (2019).

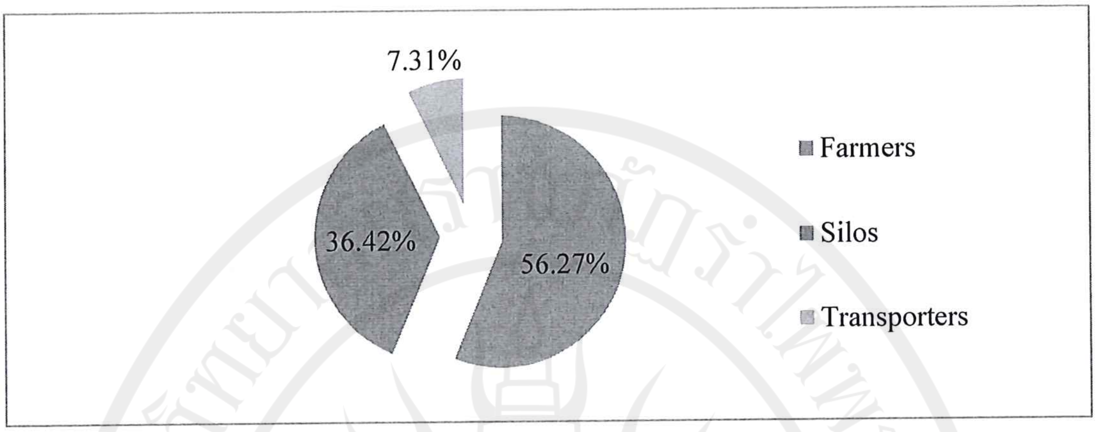


Figure 4.18 The percentage gross of profit share among from the stakeholders

The net profit represents an economic gain or loss, taking into account the predictable cost of the actual investment. The farmers are the stakeholders who gain the highest percentage of the net profit per ton, at 53.97%, as shown in Figure 4.19. However, the silos, with their great possibility of processing large volume of cassava into dried chips, which they sell to different markets, these actors obtain the highest net benefit in the value chain over one period of the production of cassava.

Moreover, the silos must meet the markets demand from the consumers and the value of the cassava will be increased according to that demand. Hence, in order to increase the value of cassava, appropriate strategies involving links and collaboration among these actors are vital. Other studies on cassava suggest that it has a good market potential and it improves the income and livelihoods of households in northern Uganda. This, however, can only be realized if cassava is processed into value added products such as starch and high quality cassava flour which has high commercial value (Odongo W & S Etany, 2018).

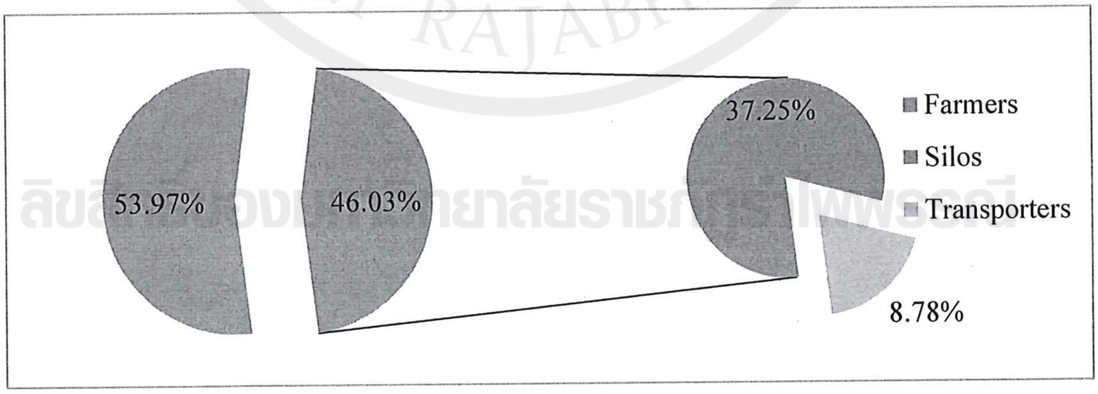


Figure 4.19 The percentage of net profit shared among the stakeholders

4.7 Constraint of cassava farmers

4.7.1 Before planting

According to data analysis, there were only 49.54% of farmers who had no problem in with the previous planting, while 50.46% had encountered some problems as shown in the left pie chart of Figure 4.20. Problems mentioned by the farmers include lack of rain (15.60%), a lack of cut stem (9.17%), high cost of cut stem (4.59%), lack of capital (8.26%) and lack of labor (12.84%), as shown in the right pie chart of Figure 4.20.

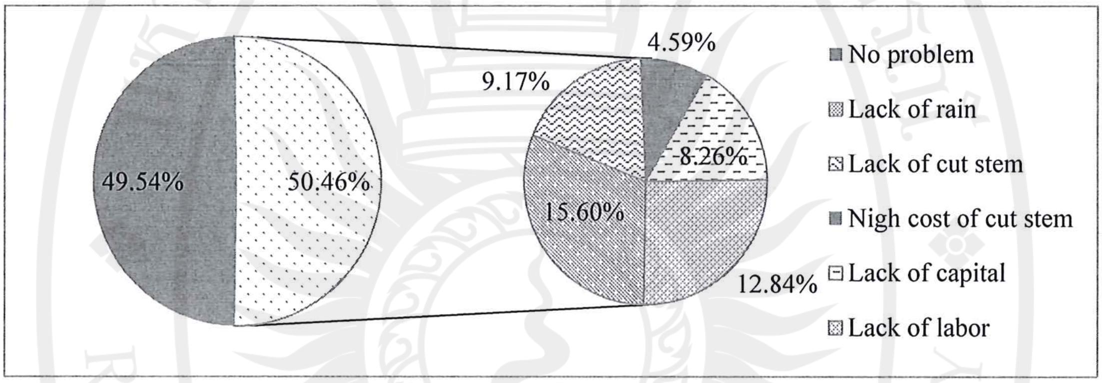


Figure 4.20 Representation of the percentage of constraints before planting

4.7.2 Maintenance

There are 45.87% of the respondents answered that they had on problems with the maintenance of cassava farming; the other 54.13% said that they had encountered some problems as shown in the left pie chart of Figure 4.21. Those problems, as shown in the right pie chart of Figure 4.21 were associated with pest (8.26%), disease (8.26%), weeds competition (10.09%), increased drought (12.84%), lack of capital (5.50%) and lack of labor (9.17%). Hence, pests and disease represented around 16 % and a big percentage of problems in study area.

For most of its cultivation history in Cambodia, cassava has been deemed to be free of pests and diseases, with yield losses due to biotic factors lower than 5% (Graziosi et al., 2016). That could explain the reason why the Cambodian farmers are often ignorant about the method and frequency of application of the fertilizers and pesticides. They do not consider the pest and disease as big problems. But over the years, continuous cropping and inappropriate farm management can lead to a net nutrient removal and a gradual decline of soil fertility. Consequently, colonized pests and complex diseases of invasive arthropod pests and plant diseases have recently come to affect local crops, with a decline in the cassava yield due to a lack of improvement in the agro-practices, year after year. Other scholars shown that most of the farmers face heavy rainfall and drought, which are recognized as a major cause in destroying approximately 40% on total yield, while pests and disease destroy around 15% on average (World Bank, 2015).

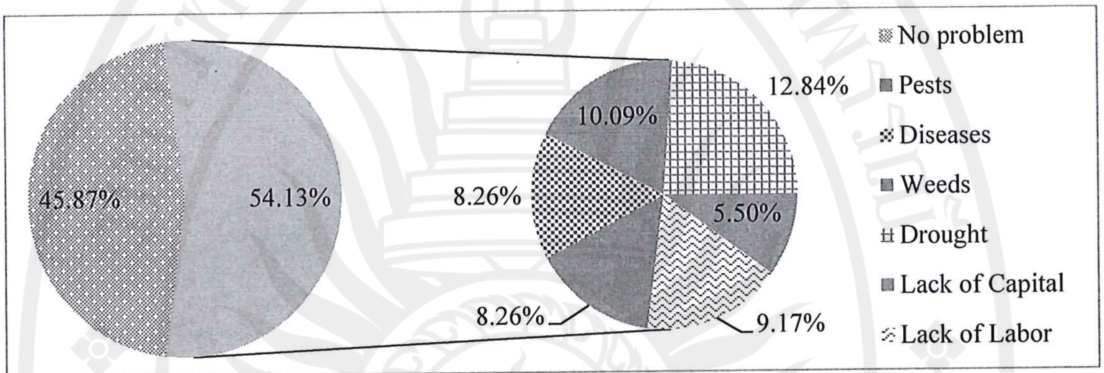


Figure 4.21 Representation of the percentage of constraints during farming

4.7.3 Harvesting

Even though all the farmers are able to harvest their cassava, 59.63% of them said that they had constraints and problems while only 40.37% said they did not have any problems during harvesting as shown in the left pie chart of Figure 4.22. The problems they face at time of harvesting are: no market (0.92%), lack of marketing information (7.34%), low price (21.10%), lack of labor (11.01%), weight discrepancy (12.84%), rainfall (5.50%) and transportation (0.92%) as shown in the right pie chart of Figure 4.22.

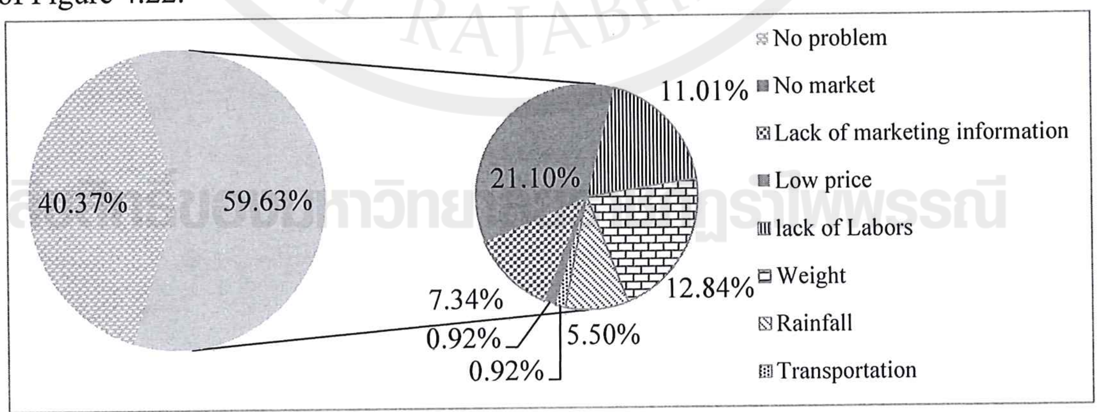


Figure 4.22 Representation of the percentage of constraints during harvesting

4.8 SWOT analysis on cassava chain

Identifying the cassava production internal Strengths and Weaknesses, and examining the external Opportunities and Threats that all stakeholders face. The main findings from this study are summarized in the SWOT analysis that follows in Table 4.15.

Table 4.15 SWOT analysis on cassava farmers

Famers	Input suppliers	Middlemen/Transporters	Silos
STRENGTHS	STRENGTHS	STRENGTHS	STRENGTHS
- Cassava is a major crop in study area, 58% of land is used in cassava farming and crop change every season - Harvesting periods can be delayed and less intensive labor than other crops - High yield of fresh root cassava at 24.16 tons per hectare - Education level of farmers is low, resulting in poor knowledge of new techniques to improve productivity - Cassava needs a longer growing period - Farmers do not know which variety is suitable for their specific agro-ecological conditions	- Provides none formal credit to cassava farming for their purchases - Multiple input supplies to farmers such as fertilizers, pesticides, herbicides, seeds and other agricultural equipment - No knowledge of chemical usage and pesticide control - Sell chemical products based on myths more than technical science - Some of them with low education	- Multiple possibilities of transport for cash crop such as cassava, maize, soybean and mungbean - Good mobilizing labor to harvest cassava for the farmers - Good collaboration with workers and farmers - Lack of knowledge about truck maintenance. - Traffic congestions	- Presence of multiple businesses due to the cash crops of cassava, maize, soybean and mungbean. - Creation of a traders association for the silos. - Good collaboration with authorities at all level and Thai traders - Lack of capital to buy cassava in the harvesting season. - Processing and transportation costs are higher than in the neighboring area

Table 4.15 SWOT analysis on cassava farmers (Continued)

Famers	Input suppliers	Middlemen/Transporters	Silos
WEAKNESS	WEAKNESS	WEAKNESS	WEAKNESS
- Labor not readily available in study areas during planting and harvesting seasons - 59 % of farmers take a loan from Banks or Microfinances - 24 % of them faced a loss from their cassava production due to large yield fluctuation (10 to 34 fresh root tons per hectare)			
OPPORTUNITIES	OPPORTUNITIES	OPPORTUNITIES	OPPORTUNITIES
- Increased cassava production is attracting more investors to the cassava business - Cassava is adaptive to a wide range of soils and can survive a moderate drought	- Cassava farms: 100% need herbicides, while over 40 % need fertilizers - Besides cassava, the farmers planted cash crops and they need seeds, fertilizers, pesticides and herbicides full year.	- Large amount of products from the farmers. And many customers available in study area. - Opportunities to get a benefit of over 2,675 USD per season from cassava	- Regional trade agreements e.g. ASEAN and China have lowered the export costs. - Improve partnerships in the local area from the policy - Opportunities to get a benefit of over 85,000 USD per season form cassava - Possibility to get benefits from other cash crops besides cassava such as maize, soybean, etc.

Table 4.15 SWOT analysis on cassava farmers (Continued)

Famers	Input suppliers	Middlemen/Transporters	Silos
THREATS	THREATS	THREATS	THREATS
- Climate Change (increase in pest, disease and drought) - Limited research and development and transfer of new techniques to farmers - Market depends on Thai traders only - Soil nutrient depletion and a yield decline over time	- Climate Change (increase in pest, disease and drought).Farmers loose profit from cassava farming and then cannot repay the supplier	- Rainfall delays the transport. - The rural trails are difficult - Difficult to mobilize labor, because most of the labor force migrate to Thailand	- Unpredictable foreign market policy - Low capital source and few local processors to absorb the produce during harvesting - Processing and transportation costs are higher than neighboring countries - Lack of investment in the processing of raw material at the local level. - Greater dependence on Thai traders compared to the Chinese traders. - Low government interest rate but severe criteria

CHAPTER V

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

From this field research, it can be concluded that the cassava farmers have a low level of education (41.29% of them have a primary school education only). So, the farmers with no or low education have difficulty in accessing information on the new techniques of production and marketing. They also have no knowledge or interest about the weather factors and the pest mitigation that can affect their crop. Therefore, their ideas on the production of cassava are more often based on myths instead on facts, like thinking that cassava does not need fertilizers or pesticides, and they sometimes use inappropriate techniques in their agro-practice. In addition, continuous cropping of cassava in the same field, without balanced fertilizer application can lead to soil nutrient depletion and a yield decline over time. Those are the reasons that we see substantial variations in this study.

The silos play a vital role in the cassava value chain, and their demand has led to the enhancement of the value of cassava roots, which is transformed to dried chips and provides animal food (CP Company). Some of the dried chips are used locally, and the rest (67.76%) is sold to Thai traders who in return, export it to Chinese markets. On the other hand, addressing the emerging opportunities and challenges in the cassava market requires cross-sectorial participation from the full range of stakeholders in the value chain, notably the government.

Through the Ministry of Agriculture, Forestry and Fishery, the government can supply credit in the form of soft loans to buy fertilizers or pesticides. In the light of the foregoing results, improving the profits of the farmers is a major challenge that will require interest from the government officials with an appropriate budget. The support from politicians of all levels is essential.

The farmers who sold cassava in the form of dried chips got 17% more benefits than the farmers who sold cassava in the form of fresh roots. The cassava production provides jobs for the local population who faces a high level of unemployment. Cassava is also a way to diversify the revenue of the farmers, although they have a lower profit than the transporters and the traders. Unfortunately, only 28.77% of the dried chips cassava is processed locally for the animal food and the rest is sold to Thai traders for exporting to the Chinese market. Consequently, this has a negative effect for the added value of the cassava production.

An inappropriate agro-practice, a low industrial processing capacity, a dependence on Thai traders for exporting to Chinese market and the volatility in the demand and supply, those are some of the biggest problems for the cassava farmers in Cambodia.

5.2 Recommendation

Government

- The Provincial department of agriculture, Forestry and Fishery and other donor partners should make massive investment in subsidizing cassava production. The farmers need help to improve the processing of their cassava locally with new technology. Lower interest loans should also be made available to the farmers, by the Ministry. There is a need for the promotion of newly introduced cassava varieties, with an appropriate strategy.
- The Provincial department of agriculture should be conducted training about soil nutrition and the 4R Nutrient Stewardship concept, pest and diseases of the cassava to cassava farmers.
- All of this would contribute to a sustainable cassava-based production system.

Cassava farmers

- The farmers should be encouraged to form themselves into viable Cooperative Groups or Associations. This would allow them to have a stronger voice when they need a bank or government loan, or when they would sell cassava as a group.
- They should accept the 4R Nutrient Stewardship concept of applying the right source of plant nutrients at the right rate, at the right time, and in the right

place. This provides guidelines on fertilizer management that will help the farmers to reap the full benefits of their investment.

- Since there is a higher benefit in the sale of dried chips, the farmers should privilege this channel.
- The farmers should find out about new varieties that are resistant to disease and drought, and that produce high yield.

Further studies

- More research into the added values analysis of all the actors, including the CP (food for Animals Company) and the Thai exporters.
- Research about climate change and the impact on the cassava production.
- Implementation of an agricultural policy (Cassava production) at sub national level in Cambodia.

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APPENDICES

Appendix A: Distribution of crop calendar's cassava farmers

Table 1: Distribution of crop calendar's cassava farmers

Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Select variety												
Maintain variety												
Plow												
Rest bed												
Planting												
Apply fertilizers												
Spaying herbicide												
Spaying pesticide												
Cleaning weed												
Spaying liquid fertilizer/hormone												
Pruning												
Harvesting												

Appendix B: Breakeven analysis formulas for cassava production

Table 2: Breakeven point analysis formulas on fresh roots

Assumption						
	Units start	**Units increment**	**Units price**	**Units Variable cost**	**Total Fixed cost**	
	0	4	61.53	34.03	235.22	
Units (T)	**Sale ($)**	**Variable Cost ($)**	**Contribution Margin ($)**	**Fixed Cost ($)**	**Total Cost ($)**	**Net Income ($)**
0	-	-	-	235.22	235.22	(235.22)
4	246.12	136.11	110.01	235.22	371.33	(125.21)
8	492.24	272.21	220.03	235.22	507.43	(15.19)
8.55	**526.08**	**290.93**	**235.16**	**235.22**	**526.15**	**0.00**
12	738.36	408.32	330.04	235.22	643.54	94.82
16	984.48	544.42	440.06	235.22	779.64	204.84
20	1,230.60	680.53	550.07	235.22	915.75	314.85
24	1,476.72	816.64	660.08	235.22	1,051.86	424.86
28	1,722.84	952.74	770.10	235.22	1,187.96	534.88
32	1,968.96	1,088.85	880.11	235.22	1,324.07	644.89
36	2,215.08	1,224.95	990.13	235.22	1,460.17	754.91
40	2,461.20	1,361.06	1,100.14	235.22	1,596.28	864.92
44	2,707.32	1,497.17	1,210.15	235.22	1,732.39	974.93
	Breakeven x	**Breakeven y**	**Label**			
	8.55	**526.23**	**BEU approx =8.55**			

Table 3: Breakeven point analysis formulas on dried chips

Assumption						
	Units start	**Units increment**	**Units price**	**Units Variable cost**	**Total Fixed cost**	
	0.00	2	151.18	78.01	227.97	
Units (T)	**Sale ($)**	**Variable Cost ($)**	**Contribution Margin ($)**	**Fixed Cost ($)**	**Total Cost ($)**	**Net Income ($)**
0	0.00	0	0	227.97	227.97	-227.97
2	302.36	156.02	146.33	227.97	384.00	-81.64
3.116	**471.08**	**243.08**	**227.98**	**227.97**	**471.06**	**0.00**
4	604.72	312.05	292.66	227.97	540.02	64.70
6	907.08	468.07	439.00	227.97	696.05	211.03
8	1,209.44	624.10	585.33	227.97	852.07	357.37
10	1,511.80	780.12	731.67	227.97	1,008.10	503.70
12	1,814.16	936.15	878.00	227.97	1,164.13	650.03
14	2,116.52	1092.18	1024.33	227.97	1,320.15	796.37
16	2,418.88	1248.20	1170.67	227.97	1,476.18	942.70
18	2,721.24	1404.23	1317.00	227.97	1,632.20	1,089.04
20	3,023.60	1560.25	1463.34	227.97	1,788.23	1,235.37
	Breakeven x	**Breakeven y**	**Label**			
	3.12	**471.04**	**BEU approx= 3.11**			

Appendix C: Questionnaire for Cassava Producers

Questionnaire code................Interviewer.................................. Date.............................
Location: Village .... Commune .... District................. Province ....
Tel: ....

I. *General information*

1. Name of respondent: .... Sex ☐ Male ☐ Female Age ....
2. Education level ☐ Illiterate ☐Grade 1-6 ☐ Grade 7-9 ☐ Grade 10-12
   ☐ College ☐Other (specify.......................
3. Number of years have you stayed in .... Before, where did live? ....
4. Number of people in your family?.........................persons

Demographic characteristics of sample respondents

No.	Name of HH members	Sex Male=1 Female=2	Age	Marital status Single=1 Married=2 Divorced=3 Widowed=4	Education level Illiterate =1 Grade 1-6=2 Grade 7-9=3 Grade 10-12=4 College= 5 Other= 99 (…)	Occupation Farming= 1 Off-farm=2 Non-farm=3 1&2=4 1&3=5 2&3=6	HH Relationship HHH=1 Father=1 Mother=2 Child=3 Son-in-law=4 Sister-in-law=5 Nephew=6 Niece=7 Grandparent=8
01							
02							
03							
04							
05							
06							
07							
08							

HH=Household, HHH=Household head

II. Land for agricultural

5. Land size do you have for agriculture? .... …………Rai/hectares, Owned .... Rent..............................

Own land

Plots	**Source of land** Bought =1 Reclaimed=2 Concession= 3 Inheritance=5 Others=99	**Date received**	**Purchase price**	**Source of Capital**	**Land register** Yes=1 No=2	**Type of crop** Rice= 1 Cassava=2 Maize=3 SoyBean=4 Mungbean=5 Mango= 6 Longan = 7 Others=99	**planted Date**	**Harvest Date**	**Yield(T)**	**Planting** Last Years	**Planting** Last 5 years
1...........Rai											
2...........Rai											

Case: Reclaimed and Concession

Plots	**Type of land** Reclaimed=2 Concession= 3	**Situation of land**				**Land mine**			**Total expense**
		First of land Bamboo forest=1 Dense forest=2 Pre-Dense forest=3 Treng=4 Other=99	**Ways deforestation** Them self by hand =1 Rent by hand =2 Them self by machine =1 Rents by machine=3	**Source Capital** Own=1 Loan=2	**Expenditure**	**Yes=1** **No=2**	**Ways demine** Own=1 Rent= 3 CIMAC=4	**Expenditure**	
1.....Rai									
2.....Rai									

2. Do you have to rent land for cassava cultivation? ☐Yes ☐No
If (No Please skips this question)

Plots	**Date planted**	**Date Harvested**	**Yeild(T)**	**Planting** Last Years	**Planting** Last 5 years	**Price per season**
1..........Rai						
2..........Rai						
3..........Rai						

III. Situation of cassava (Last season)

History of cassava cultivation

1. What year did you start to grow cassava? ....
2. Why did you start to grow it? ....
3. How many Rai/hectares did you plant the first time?...................................
4. Before cultivating cassava, what crops did you plant on this land? ………..
5. Where did you get variety for planting?

☐ Local variety (Name: ……………………………………………………..

☐ Outside Variety (Name: ………………………………………………….

☐Thai ☐Vietnam ☐Malaysia ☐ China ☐Others …………………..

6. Where did you obtain technical knowledge on planting cassava?

☐ Self-taught ☐ Family ☐ Neighbors ☐Government ☐ NGOs ……

Calendar of cassava farming

Activity	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Select variety												
Maintain variety												
Plow												
Rest bed												
Planting												
Apply fertilizers												
Spraying herbicide												
Spraying pesticide												
Cleaning weeds												
Spaying hormones												
Pruning												
Harvesting												

Cassava variety for planting now

1. Last season, how man Rai/hectares of cassava did you plant? ……………...
2. What type of variety cassava? Name ....
3. Why did you plant this variety? ……………..……………………………..
4. Where did you get this variety for planting?

☐Their self ☐your family ☐Bought ☐ NGO ……. ☐Others ……

If bought, how much is it per unit? ..../Unit, how many units per Rai/hectares?

5. Why you do need to buy this variety?………………………………………

6. How long do you have to wait to do cassava the harvesting, after doing planting ? ……..………………………...
7. Dou you keep a variety for the next season? ☐ Yes ☐No (why…………
8. Please detail how you keep a variety of cassava? …………………………

Land preparation

1. How many times do you plow before planting?

   ☐1 time ☐2 times ☐ 3 times (why?...
2. How many days do you sterilize your field (By sunlight) before planting?
   …………………………………………………………………………………

Cultural practice

1. How do you plant cassava? ☐Horizontally ☐Vertical ☐Inclined
   Why? ……………………………………………………………………..
2. Please give detail how to plant cassava (Technique of cassava producer)

Technical	Methodology
– Plough – Size of bed row – Height of bed row – Distance of bed rows – Distance of stakes – Depth of stakes	

Cassava management

3. Is cassava crop difficult to take care of? ☐Yes ☐No
   Why? ………………………………………………………………………..
4. What is your main focus for maintenance? Please rank (1 2 3 4 5………9)

   ☐Pest ☐Disease ☐Weed ☐Plant nutrient ☐Others (…………
5. What is the main factor to impact your cassava yield? (1 2 3 4 5………9)

   ☐Pest ☐Disease ☐Weed ☐Soil ☐Variety ☐Maintain

   ☐Climate changes ☐Others (…
6. Do you apply fertilizer on your cassava farm? ☐Yes ☐No
   (If no skip to question 8)
7. How much times do you apply it? ☐1 time ☐2 times ☐ 3times

First time, how many units? …..……. Units, How much per unit? ……………

☐Compost fertilizer ☐Chemical fertilizer ☐Compost/Chemical fertilize

☐ Hormone ☐Others (Why…………………………………………

Second time, how many units? …..……. Units, How much per unit? …………

☐Compost fertilizer☐Chemical fertilizer ☐Compost/Chemical fertilize

☐ Hormone ☐Others (Why? …………..………………………………

Third time, how many units? …. Units, How much per unit? ………………….

☐ Compost fertilizer ☐Chemical fertilizer☐ Compost/Chemical fertilize

☐ Hormone ☐Others (Why? ……..…………………………………………....

8. Do you use pesticide chemical? ☐Yes ☐No (If no skip to question 9)
First time, how many units? ……… Units, How much per unit? ………………
Name of pesticide chemical: ………………………..Make in…………..…..
Why? ………………………………………………………………………………
Second time, how many units? ……… Units, How much per unit? ...…………
Name of pesticide chemical: ………………Make in………………..………..
Why? ………………………………………………………………………………
Third time, how many units? …….…. Units, How much per unit? ……………
Name of pesticide chemical: ……………………………Make in……………....
Why? ………………………………………………………………………………

9. Do you use herbicide chemical? ☐Yes ☐No (If no skip to question 10)
First time, how many units? ………… Units, How much per unit? ……………
Name of pesticide chemical: ………… …Make in…………………………..
Why? ………………………………………………………………………………
Second time, how many units? ………..… Units, How much per unit? ...………
Name of pesticide chemical: ……………..……Make in……………………
Why? ………………………………………………………………………………
Third time, how many units? …….…. Units, How much per unit? ……………
Name of pesticide chemical: ………………………..Make in……..…………...
Why? ………………………………………………………………………………

10. Do you use hormones? ☐Yes ☐No (If no skip to question IV)
First time, how many units? ……..…. Units, How much per unit? ……………
Name of hormone chemical: …………………… Make in ……………..……..
Why? ………………………………………………………………………………
Second time, how many units? …..…… Units, How much per unit? …………
Name of hormone chemical: …………………………Make in ………………
Why? ………………………………………………………………………………
Third time, how many units? ………. Units, How much per unit? ……………
Name of hormone chemical: ………………… Make in ……………………..
Why? ………………………………………………………………………………

IV. Cassava production efficiency
Capital source

1. Do you have to loan for cassava farming? ☐Yes ☐No (If no skip to question Variable cost)
2. Where do you loan? ☐Bank ☐ MIF ☐Middle man ☐Relative

Name of loan	Amounts	Rate	Months	Regulation	Season(Why)

3. Compared to 5 years ago, Do your loan for cassava farming is increase?

☐Yes ☐No (Why ………………………………………………………

Variables cost

Items	Land size (Rai/Ha)	Quantity	Unit Cost	Total Cost	Others Them self =1 Rent=2
Stem cutting					
Chemical Fertilizer					
Compost Fertilizer					
Herbicide					
Pesticide					
Hormone					
Gasoline					
Bags					
Line					
Plow					
Rest bed					
Transport					

Labor

Specific Activity	Quantity Rai= 1 Hectares=2	Units Person=1 Days=2 Rai=3 Hectares=4 Tone=5 Truck=6	Labor Family=1 Hired=2	Cost units	Total
Planting					
Plow					
Rest bed					
Cleaning weed					
Fertilizing					
Spraying Herbicide					
Spraying Pesticide					
Spraying hormone					
Pruning					
Harvest (Digging/Cutting)					
Drying (Chip cutting & Drying)					
Carrying					
Transport					

Fixed cost

Asset	Quantity	Unit cost	Years bought	Life cycle (year)	% used in cassava farming	Others
Tractors						
Truck						
Machine spaying						
Machine cutting grass						
Storage						

Harvesting

1. Do you have a delay in cassava harvesting when the price goes down?

☐Yes ☐No

If (yes...

If (No ....

2. What kind cassava do you like to sell? ☐Fresh roost ☐Dried root

Why ....

3. How many differences between a ton of fresh Cassava are lost when drying? ....
4. How many days do you dry cassava? ......days
5. How many labors involve with dry cassava? ....Person Cost ....
6. Who do you like to sell cassava? ☐Collect trader ☐Silo ☐Others

Why ....

7. Why you know the price cassava? ....
8. How many tons did you got from cassava farming? ....Tones

Land size (Rai/Hectare)	Date	Yeild (T)	Selling (T)					
	Planted	Harvested	Fresh	Dried	Price/T	Whom collector=1 Silo=2	where Silo=1 Orchad=2 Home=1	Expenditure
Plots 1								
Plots 2								
Plots 3								

V. Analysis of problems and constraints

1. What are the problems you encounter during the planting season of cassava? (Rank 1 2 3..9)

☐ No rain fall ☐Lack of stem cutting ☐ stem cutting expensive

☐Lack of capital ☐Lack of labor ☐Other

Specify the main reason ....

Solution: ....

2. What are your problems with cassava maintenance? (Rank 1 2 3..9)

☐ Weed ☐Pest ☐Disease ☐Drought ☐Lack of labor

☐Lack of Capital ☐Other (……………

Specify the main reason …………………………………………………………

Solution: ……………………………………………………………………………

3. What are your problems with cassava on harvesting season? (Rank 1 2 3..9)

☐ Rain ☐Lack of labor ☐Lack of Capital ☐Other (………………

Specify the main reason …………………………………………………………

Solution: ……………………………………………………………………………

4. What are your problems with cassava at time of selling?

☐ Lack of trader ☐ Low price ☐Scale unreliable ☐Other (…………

Specify the main reason …………………………………………………………

Solution: ……………………………………………………………………………

5. Did you have any suggestions to improve your cassava production?

☐Yes,☐No

If yes, What suggestion? ……………………………………………………………

Thank you very much for your time!

Appendix D: Questionnaire for Cassava traders

Questionnaire code .... Name Interviewer.......................... Date..............

Location: Village ....Commune ....District.................... Province ....

Tell: ....

☐Collectors ☐Silo

I. Personal Information

1. Respondent's name..............................; Sex: ☐M ☐F; Age:..........
2. Respondent's marital status: ☐Single ☐Married ☐Widow/ Widower
3. Education level of household head: ....year of schooling
4. Type of respondent's shelter (describe materials):....................................
5. Household size: ______ persons; Male______ Female______
6. No. of family members help in your business: ______ persons
7. Hired workers: ______ person, Salary ....
8. Why do you need this number of workers?
9. How many business/career do you have?
10. What are they?
11. Why are you interesting in cassava business?
12. Type of ownership: ☐Single proprietorship ☐Partnership ☐Family business

    ☐other (specify......
13. Years in cassava trading: ....
14. Area coverage ....
15. What about is the Land for your business? ☐Own ☐ Rents

    If rent, Please provide details...

II. Marketing Operation

Bought cassava

1. Where do you buy cassava from?

   Diststrict ....

   Province ....
2. Who are your suppliers? ☐Famers ☐Collect traders ☐ Agents

   ☐Others..........
3. Do you have suppliers under contract with you? ☐Yes ☐No

   (If no please skip to questioner 4)

   Number Famers.......................... Regulation ....

   Number Collect traders.................. Regulation ....

   Number Agents.......................... Regulation ....

   Number others........................... Regulation ....
4. Who do you prefer to buy from?

   ☐Famers ☐Collect traders ☐Agents ☐others (specify.........

   Please detail...

5. What form of cassava did you buy? ☐Dried chip ☐Fresh roots ☐All form
6. What form do you prefer to buy? ☐Dried chip ☐Fresh roots
   Please detail..
7. Who determines the price of cassava?
   ☐Gov. ☐Thai traders ☐Chines Trader ☐Others
8. According to your business over the last 5 years, what is the trend for the price of cassava?
   ☐ Increase ....
   ☐ Decrease ....
9. What factors considered in pricing cassava? ☐Prevailing price ☐Previous price ☐Expected price ☐Quality ☐Credit tie-up ☐Good relations ☐other (specify)..
10. Who are the main suppliers? ☐ Famers ☐ Collect traders ☐Agents
    ☐Others (specify...
11. Last season, how many tons did you buy?
    Fresh roots .... Tons
    Dried chip .... Tons

12. Details of purchases for the traders during the last season

Time of purchase **Dec=1** **Jan=2**	Form of cassava **Fresh roots=1** **Dried chip=2**	Location of purchase **Silo=1** **Field=2**	Supperyer **Farmer=1** **Village trader=2**	Volume bought (Kg)	Price/Tonne	Tearm Payments

Cassava sold

1. Do you have contract with customers? ☐Yes ☐ No
   Please detail...
2. Who are the main customers? ☐ Thai traders ☐ Chines Trader ☐ Chines Trader ☐Others (specify...................................
3. What form do you prefer to sell? ☐Dried chip ☐Fresh roots
   Please detail...
4. Last season, how many tons did you buy? Fresh roots .... Tons , Dried chip ....Tons
5. Details of the sales of cassava by the traders during last season

Time of sold **Dec=1** **Jan=2** **.......**	Form of cassava **Fresh roots=1** **Dried chip=2**	Sold to **Silo=1** **Thai=2** Others (specify......	Customers **Farmer=1** **Village trader=2**	Volume sold (Kg)	Price/Tonne	Tearm Payments

III. Capital source

1. Did you get financial aid (Capital source) from others? ☐Yes ☐No (If no please skip to questionnaire 4)
2. Who did you get financial aid? ☐Gov.-UNDP ☐ Thai traders ☐ Vietnam Trader ☐ Chines Trader ☐Others (specify ....
3. How did about you contact your financial aid? ....
4. Did you have to take a loan for your business? ☐Yes ☐No

Source of loan	How much	Annual Interest Rate	Loan term	Condition	Reason

5. Compared to 5 years ago, Do your loan for cassava business is increased?
   ☐Yes ☐No
   Why ....

Variable cost (fresh root)

1. How many days/months does it take to process your fresh root to dried chip?
   ....
2. How much amount of weight loss when you transform one ton of fresh roots to dried chip? ....

List Variable cost incurred, per metric ton of cassava

Items	Unit	Cost unit	Labor Farmily			Hired Labor			Total
			F	M	Unit	F	M	Unit	
Drop cassava down									
Cutting cassava root									
Drying cassava									
Collect cassava									
Storage									
Transportation									
Staffs									
Gasoline									
Phone cards expenditure									

Variable cost (Dried fresh root)

1. How many days for you storage dried root? ....
2. How many ton of Cassava are lost when storage? ....

List Variable cost incurred per metric ton of cassava

Items	Unit	Cost unit	Labor Farmily			Hired Labor			Total
			F	M	Unit	F	M	Unit	
Drop cassava down									
Cutting cassava root									
Dry cassava									
Collect cassava									
Storage									
Transportation									
Gasoline									
Cards exspenture									
Taxe									

List fixed cost

Items	Unit	Unit Cost	Purchase Years	Life cycle	% using
Truck					
Machine cutting					
Weighing scale					
Warehouse/building					
Campus drying					
Salary					
Office Equipment (phone/fax, internet,)					
Land rental cost					
Tax					

IV. Problems and constraints

Problems and constraints (Input, production, technology, marketing, quality assurance, policy, basic infrastructure, labor and skill, etc)	**Possible Solution**

1. Do you have any suggestion? ☐Yes ☐No
   If yes, what suggestion?
   ………………………………………………………………………………………….
   ………………………………………………………………………………………….
   ………………………………………………………………………………………….
   ………………………………………………………………………………………….

Thank you very much for your time!

Appendix E: Guide Question for Input Supplier

I. General Information

Name of respondent .... Sex ☐ Male ☐Female (Age ....)

Education level ,☐ Illiterate ☐Grade 1-6 ☐Grade 7-9 ☐Grade10-12

☐College ☐Other (...

Key questionnaires

1. How many years have been selling your products?
2. Do you have skills about the use of chemical in agricultural? ☐Yes ☐No
3. What types of agricultural products do you sell?

   ☐Herbicide ☐Pesticide☐Fertilizer ☐Hormone ☐Other ....
4. From which county your products come from? ☐Thailand ☐Vietnam

   ☐ China
5. What volumes is your selling each year?
   Thailand...
   Vietnam
   ....
   China ....
6. Which product is highest demand from the cassava farmers?

   ☐ Herbicide ☐Pesticide ☐Fertilizer
7. For herbicide products, which country is the most popular for cassava farmers?

   ☐ Thailand ☐Vietnam ☐ China
8. For pesticide products, which country is the most popular for cassava farmers?

   ☐ Thailand ☐Vietnam ☐China
9. For fertilizer products, which country is the most popular for cassava farmers?

   ☐ Thailand ☐Vietnam ☐China
10. For hormone products, which country is the most popular for cassava farmers?

    ☐ Thailand ☐Vietnam ☐China

11. list prices to sold of products for cassava farming

Items	**Unit**	**Normal price**		**Price rate**		**Terms Months**	**Source of Product** Thailand=1 Vietnam=2 China=3
		Price/Unit	**Total**	**Price/Unit**	**Total**		
Herbicide							
Glyphosates							
48							
Pesticide							
Deltamethrin							
Fertilize							
Hormone							
Fungicides							

12. Compared to 5 years ago, are the demands for agricultural products of cassava farming increasing? □Yes □No
Why ....
13. What are the challenges/ constraints you have faced in selling agricultural products to farmers? (What are the feasible solutions?)

....
....
....
....

Thank you very much for your time!

Appendix F: Pictures of research activities

Figure F 1. Cassava field trip

Figure F 2. Cassava harvesting by farmers

Figure F 3. Input suppliers

Figure F 4. Pesticides and liquid fertilizers

Figure F 5: Interviwe with trader (Silo)

Figure F 6: Group dicusion with disctict authorities

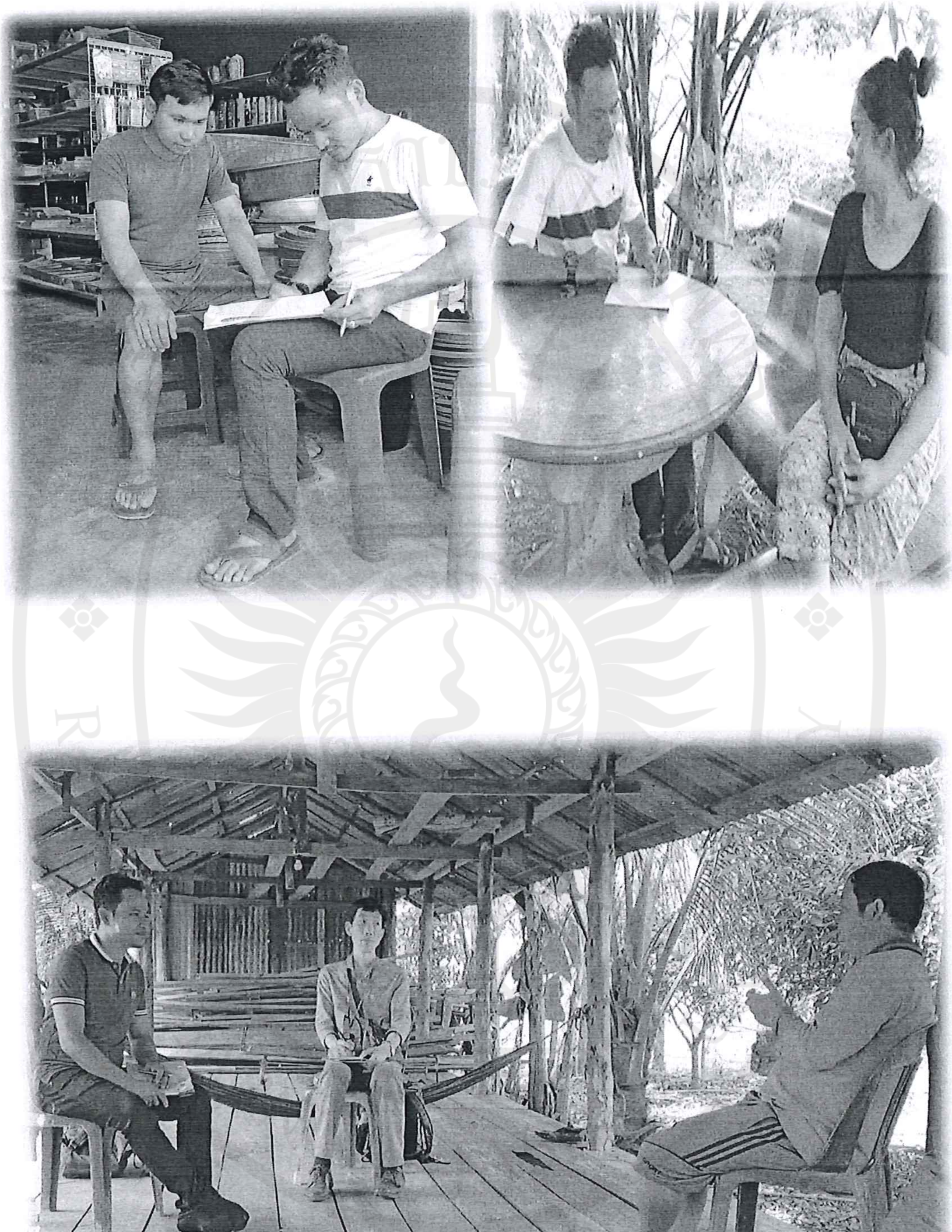

Figure F 7. In-depth interview with cassava farmers and key cassava person

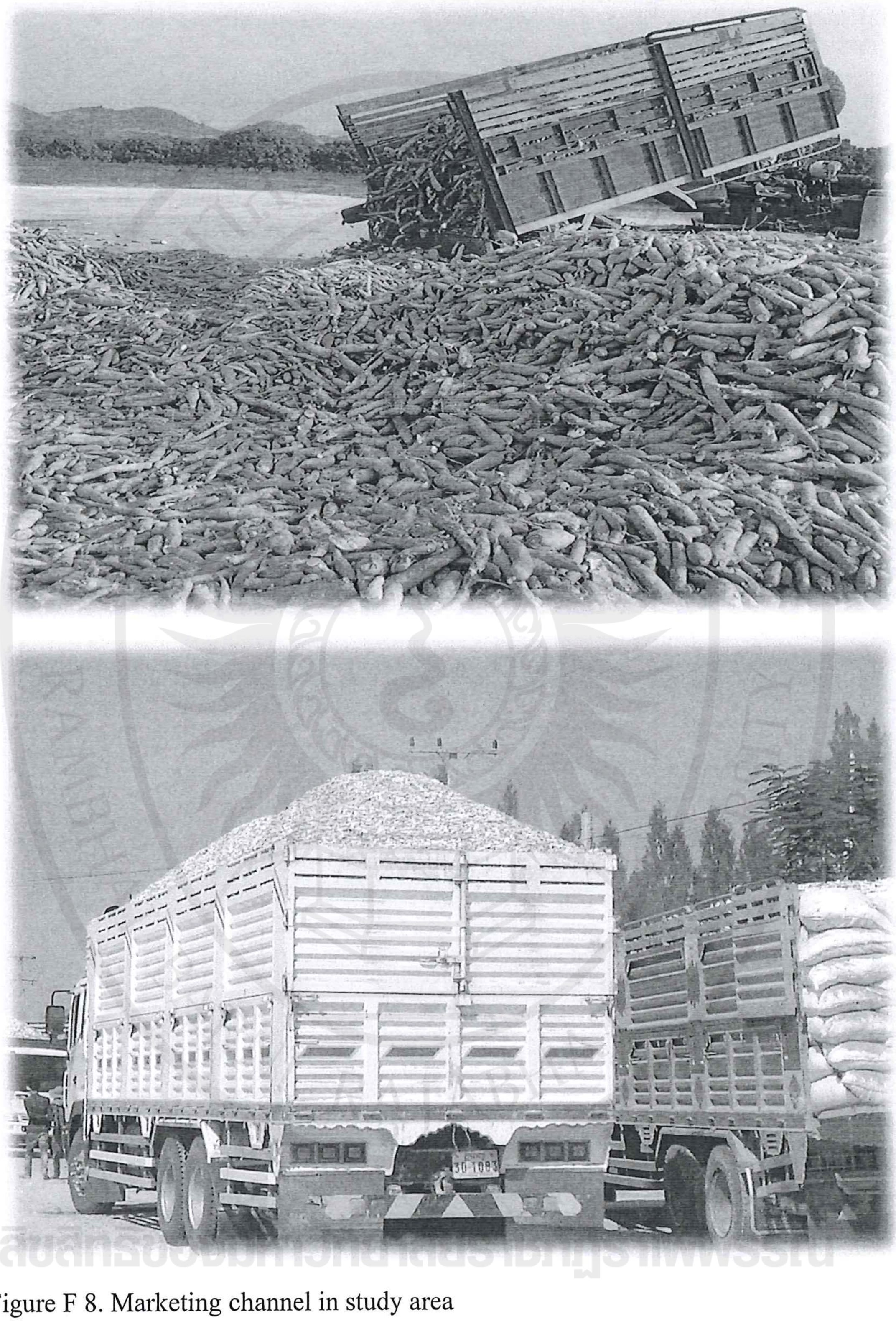

Figure F 8. Marketing channel in study area

BIOGRAPHY

NAME	Mr. Peuo Vibol
DATE OF BIRTH	January O1 1987
PLACE OF BIRTH	Battambang Province, Kingdom of Cambodia
INSTITIONS ATTENDED	Royal University of Agriculture (RUA), 2005-2009 Bachelor of Science (Agricultural Economic and Rural Development) National Institute of Education (NIE), 2012-2013 Teacher with Higher Education (Agriculture) Rambhai Barni Rajabhat University, 2018-2020 Master of Science (Agricultural technology)
SCHOLARSHIP RECEIVED	Her Royal Highness Princess Maha Chakri Sarindhorn for education project to Kingdom of Cambodia.
RESEARCH GRANTS	Faculty of Agricultural Technology, Rambhai Barni Rajabhat University
HOME ADDRESS	#47/SK.CampongPreang,Sangke/Battambang Province, Kingdom of Cambodia. Tel.012 500 451 E-mail : pouevibol@yahoo.com
EMPLOYMENT ADDRESS	National University of Battamabang E-mail: peuo.vibol@ubb.edu.kh
AWARD RECEIVED	(Peuo et al., 2020). Economic analysis of cassava production in Cambodia. International Journal of Agricultural Technology 17(1):277-290. (Peuo et al. 2020). Analysis of the cassava yield variation at Cambodia-Thailand border. Asain Journal of Agricultural and Enviromental Safety, 2020 (1):17-27.
PRESENTATION	Cassava value chain at Pursat province, Cambodia. The 9th International Conference on Art and Culture Network 2019 on Feb 11th-13th, 2019, At Nakorn Prathom Rajabhat University, Nakorn Prathom, Thailand.